Identifying flexibility in the Open Innovation process based on Real Option Theory

Master thesis

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Master Thesis

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Management summary

PROBLEM TO BE SOLVED: In the open innovation (OI) process managers of firms face an array of options at different stages of the innovation process. The problem of choosing a course of action that would lead to better innovation outcome with less overall risk for the firm exists. Thus, a method offering an improved and sophisticated decision-making is needed.

NEED: In order to provide managers with a framework, that if followed, will lead to reduced overall risk one needs to: *gain insight* about the amount of risk companies face when engaging in OI; *find* where the risk comes from and provide a scenario analysis for different outcomes of OI. Moreover, this research is based on operationalising *flexibility* in different stages of the OI process. *Analysing* resulting scenarios and accounting for trade-offs, leads to creating an algorithm at the disposal of management for better decision-making.

HOW TO SOLVE THE PROBLEM: This research aims to solve the problem by developing a model to analyse the risk of innovating by *identifying sources of flexibility in an OI project and assessing* its value under the lens of Real Options Theory (ROT). The model will serve management to come up with more effective innovation strategies.

RESULT OF THE WORK: My work analyses innovation uncertainty at different stages of the OI process of a firm. Also, the risk of different paths of innovation that can be undertaken will be compared under a Real Options (ROs) lens. This analysis provides a model and an algorithm based on that model, which advises how to achieve less overall risk and improve OI strategy, based on the presence of flexibility in operations. Providing a checklist of flexibility points is the core of the model. Moreover, this theoretical checklist will be applied to real OI projects for comparing managerial decisions in accomplishing goals, outlining best practices.
All in all, the result of this work provides proactive management with the freedom to apply the created algorithm at each decision-step in the OI process and advise for a choice of a decision or a decision path that is better than other action possibilities.

***Keywords**:* open innovation, real options, flexibility, management, decision-making

"A fascinating aspect of flexibility options is that in certain cases it is possible to estimate their value precisely. Often, the extra value added by flexibility is completely missing from such traditional valuation methodologies as net present value (NPV) techniques. In fact, one contributing factor to underinvestment ... may be the slavish dedication of MBA-trained managers to NPV. Have you ever sat at a meeting and listened to a careful NPV analysis, known in your gut that the recommendation had to be wrong, but could not put your finger on the reason? The missing ingredient may be the value of flexibility."[1]

[1] Copeland,T., Weiner, J. (1990).

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List of abbreviations

CFs - Cash flows

DTA - Decision Tree Analysis

FCs - Fixed Costs

IBM - International Business Machines Corporation

IP - Intellectual Property

IPR - Intellectual property Rights

IT - Information Technology

JV - Joint Venture

MIT - Massachusetts Institute of Technology

NPV - Net Present Value

OI - Open Innovation

OS - Operation System

PV- Present Value

R&D - Research and Development

RO - A real option

ROI - Return on Investment

ROT - Real Option Theory

WIPO - World Intellectual Property Organisation

WP- Windows Phone

List of symbols

σ - Uncertainty

δ - Dividends

r - Risk-free rate of return

S – Underlying asset value of a real option

t – Time to expiry

X – Exercise price of a real option

1 Introduction

1.1 Research context and project motivation

The focus of this thesis corresponds to the increased relevance of OI[2] and is accounting for the importance of human capital in the face of managerial decisions throughout the process. Globalisation has changed the business environment and the way companies operate. Due to worldwide competition firms have to focus on faster product development, better quality, and innovativeness.[3] Furthermore, knowledge has become more multidisciplinary and more broadly located, making innovation efforts riskier and more expensive. In order to meet these new challenges companies need to adopt new approaches to innovating.[4] To counteract market and technology uncertainty companies are required to build up flexibility in operations and business development.[5]

Science and technology progress so rapidly that it is becoming impossible for a single company to cover all advances in a field.[6] Thus, tapping into new sources of business ideas can help overcome this challenge. Therefore, nowadays, most of the NPD brought to the market are from the collaborative work of innovating partner firms.[7] More and more companies open their innovation processes and one witnesses a shift towards an OI paradigm.

While engaging in OI, firms face an array of opportunities at different stages of the process. OI is an undertaking that involves a lot of uncertainty and risk. Sometimes, it leads to faster innovation with higher returns, but often it leads to failures. The investment needed to introduce an innovation to the market is huge. However, the possibility that this innovation will fail is very high. According to existing studies, only one in a hundred innovation ideas are successful.[8] Therefore, companies with robust OI capabilities are more effective in their operations.[9] Moreover, an engagement in OI is a long-term strategic decision of companies.[10] Thus, the problem that arises for management is to choose a course of action that would lead to a good innovation outcome with less overall risk for the firm. Better return on investment (ROI) is sought

[2] There are currently 106695 publications on OI just in the database of jstor, 1262 of which are published from 2010 on. (as of March 10th).
[3] See Lindegaard, S. (2011a), p. vii; Vanhaverbeke, W., et al. (2008), p. 251.
[4] See de Backer, K., Lopez-Bassols, V., & Martinez, C. (2008), p. 7.
[5] See Lint, O., & Pennings, E. (2001), p. 163.
[6] See Lindegaard, S. (2011 a), p. 16.
[7] See Schiele, H. (2006), p. 926; Tether, B.S., (2002), p. 964.
[8] See Kang, Y. (2007), p. 18.
[9] See Jaruzelski, B., & Holman, R. (2011, May 3).
[10] See Kang, Y. (2007), p. 20.

for and management tries to limit the downside of OI investments. Firms try to make the most out of their investments by exploiting the value of time, information, and reversibility of decisions. Thus, a method offering a considerably more sophisticated decision-making, with less relying on gut-feeling and more analysis is needed.

Therefore, the central goal of this master-thesis research is:

To identifying sources of flexibility at different stages of an OI project, and asses the value of these different kinds of flexibility by means of ROT.

Innovation research is diverging to the issue of openness and scholars are predominantly interested in the collaborative efforts, information disclosure, and sharing on all levels between companies. In this paper a ROs framework to model managerial decision-making is applied in the case of firms engaging in OI. Since OI is necessary, complex, and difficult to implement it becomes important to manage this process better, to know when to switch production and inputs, delay, or abandon an OI project. Due to its inherent characteristics, ROT can be used to formalise this uncertainty on a theoretical level. What this paper contributes to academic research, is partially filling in a research gap[11] by combining existing studies on OI and ROT. The focus of this thesis narrows down to operationalising one key variable present in the two fields - flexibility.

For practitioners it is important to gain insights about the amount of risk that companies face when engaging in the OI investment cycle. Thus, the intended contribution of this work on the practical level is constructing an easily-applicable algorithm for better decision-making by listing flexibility points in different stages of the execution of an OI project. These flexibility points are linked to the ROs levers. Moreover, it is assumed that the flexibility present at each stage can be influenced by management - either management can take actions that would create this flexibility, increase it, or act in a way that existing flexibility is utilised. Thus, the model will provide management with an alternative tool to help it make more sophisticated decisions with better outcomes in the OI process.

[11] See Estrada, I., de la Fuente, G., & Martin-Cruz, N. (2010), p. 1195.

1.2 Research objectives

To achieve the central goal of this thesis a clear understanding of current research in the field of both OI and ROT is needed. A justified research gap exists. Vanhaverbeke et al. (2008) state that "Corporate venturing can (thus) be analysed both in terms of open innovation and real options and it is rather surprising that nobody so far has connected open innovation to real options reasoning."[12]

Numerous studies model complex innovation processes and the corresponding managerial decisions.[13] However, not enough stress is put on understanding the inherent characteristics and risks of the OI process. Leslie and Michaels (1997) believe insufficient attention has been paid to the determinants of option value that identify the flexibility to take action in ways that will enhance the value of acquired options.[14] Huizingh, E. (2010), states that "What is missing is a decent cookbook, an integrated framework that helps managers to decide when and how to deploy which open innovation practices. In what stage of the innovation process is collaboration most effective? With which parties to collaborate and how to find and select them? What is the best way to capture value in collaborative networks...?"[15]

An objective of this work is to partially fill in that gap. This research aims to uncover the advantages of looking into OI through a ROs lens. Many links can be established between these fields of study, but the focus here is on operationalising flexibility.

Flexibility will be used to make the connection and justify RO valuation of OI engagements. First, a link between OI and ROT will be established on a theoretical level. Then, different kinds of flexibility will be listed for the stages of an OI project and factors that increase or decrease that flexibility will be outlined. Thereafter, a checklist will be provided to allow management a better decision-making in openly innovating companies. Solutions to the stated practical problem will be put to a test: do they all follow the same major decision points. Do companies have a formal innovation system? At which stage of the project does the company choose to partner up? Which criteria are used to choose a good partner?, etc. An empirical illustration of how this proposition works, accounting for market and company-specific information will involve reviewing cases of different OI projects within firms in different industries and with different approaches to OI. Resulting generalisations will shed light on the

[12] Vanhaverbeke, W., van de Vrande, V., & Chesbrough, H. (2008), p. 252.
[13] See Katzy, B .(2003).
[14] See Leslie, K., & Michaels, M. P. (1997), p. 7.
[15] Huizingh, E. (2010), p. 6.

variables and the processes that increase a firm's flexibility and enable researchers to develop tools supporting metacognition in similar contexts.[16]

1.3 Outline

Understanding of the thesis's structure is aided by *Figure 1*. After this concise introduction, the next chapter presents an overview of the main research concepts. The process of OI is outlined: where and how it emerges, how companies actually open their innovation processes and how one measures its success. Chapter *3 Real Option Theory* introduces different ROs and the advantages and disadvantages of ROs as a valuation tool are briefly explained. A method of valuing these options is also presented. Moreover, in chapter *4*, flexibility is specified as a linking variable between the two research concepts of OI and ROs. These chapters build the conceptual framework used to explore my research question. Identifying and valuing flexibility in OI projects through ROs is justified as a base for connecting those two fields of research, allowing further analysis. Moreover, the role of management in taking decisions and optimising OI outcomes through pulling RO levers is outlined.

A theoretical model presenting flexibility as a determinant of ROs value in different stages of an OI project is constructed. The methodology chapter *5* is followed by an empirical illustration of the model in chapter *6*. Secondary data from case studies on OI projects form three companies operating in different industries is used to convey theory to practice. Flexibility at different stages of OI projects is valued and related to ROs.

A results and practical section ends my ambitious undertaking of attempting to link OI and ROT. My research concludes with general remarks, limitations and advice for further scientific investigations on the topic.

[16] See Edelson, D. (2002), pp. 115-118.

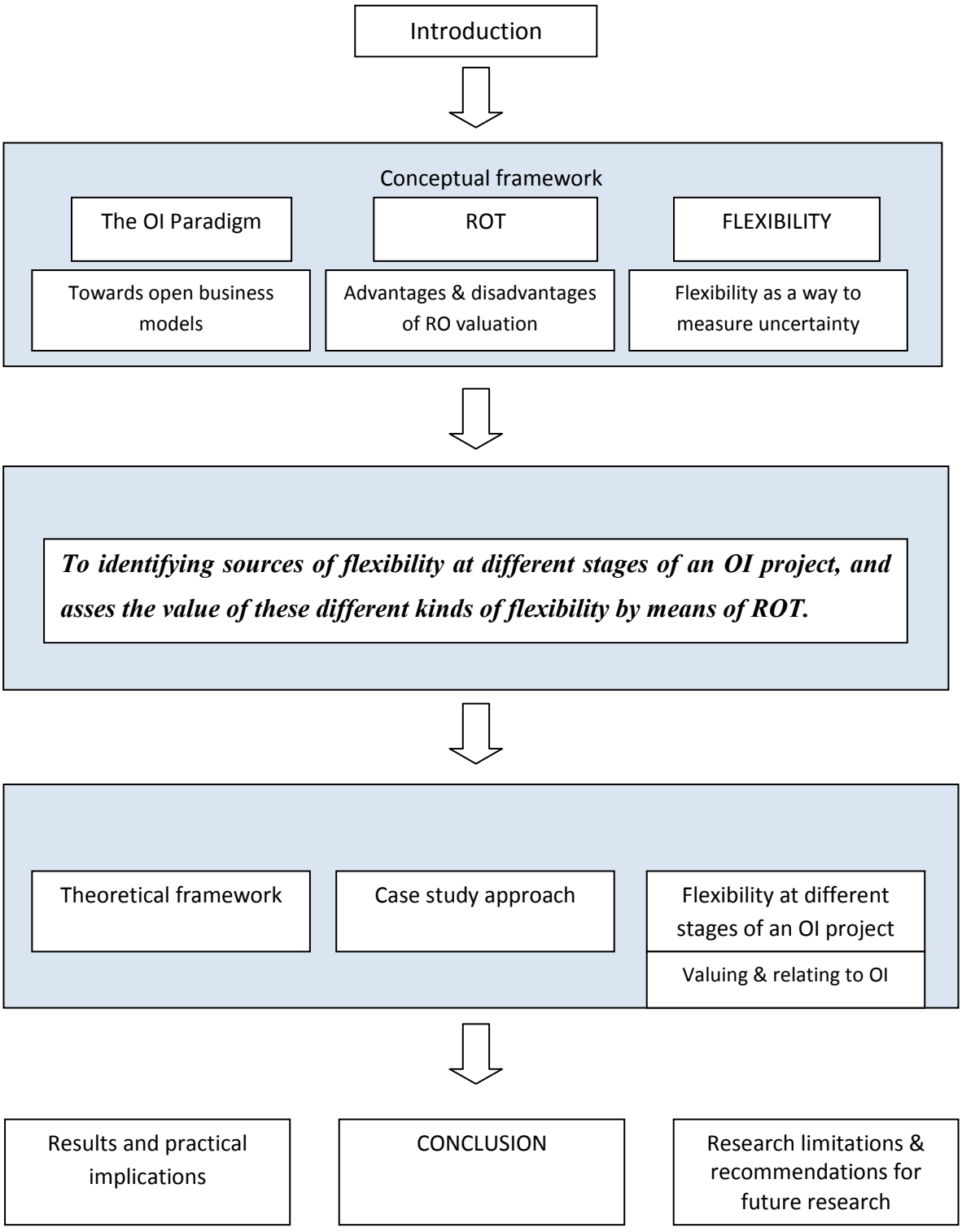

Figure 1: Structure of the master thesis

2 OI paradigm: definition and assessment

2.1 Towards open business models

2.1.1 What is OI and why it emerges: environmental and company-specific features

The method of innovation includes development of ideas, their refinement and bringing to the market where they are expected to achieve profit for the firm.[17] In that way, innovation creates business value and is a prerequisite for a sustainable firm development and growth. However, there is a lot of uncertainty involved in innovating and implementing an innovation. "Most innovations fail. And companies that don't innovate die"[18] - that is the underline of how companies embrace organisation-specific, market, technical and competitive risk in order to take their chance at sustainability and growth. Therefore, effective innovation is a strength of successful companies.[19]

Nowadays no firm can afford to continue innovating in a vacuum. There is an increased importance of speeding up innovation using both internal and external leads at all stages of the innovation process. Companies need to look inside-out and outside-in, across all aspects of the innovation process, including ideation, development, and commercialisation. Thus, the OI model is gaining momentum. It "... assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology…and systems whose requirements are defined by a business model."[20]

OI is a dynamic approach where companies actively seek ideas from both inside and outside to balance internal capabilities and external resources.[21] In doing so, much more value is created and realised throughout the process. Through OI, opportunities become more visible and companies can experiment and produce at lower costs through knowledge sharing, formal and informal networks, mobility of information and human capital. This dual nature of approaching innovation creates flexibility for a company, rationalising investments in OI. In a recent study by InnoCentive (2012) companies name as a main reason for engaging in OI projects the solving of business challenges that cannot be solved internally. Other reasons are to foster more collaboration among internal divisions, to leverage both internal and external talent resources and accelerate

[17] See Morris, L. (2008), p. 2.
[18] Chesbrough, H. (2003).
[19] See Zhang, X., & Zeng, P. (2007), pp. 24-25.
[20] Chesbrough, H. (2003), xxiv.
[21] See Pontinskoski, E., & Asakawa, K. (2009), p. 375.

the ways of getting a product to the market. Companies also point out as reasons fostering collaboration with partners and suppliers and outpacing competition. Generally, an OI project is based on information and ideas from different parties, but is executed by the company that values it the highest. A failed project for one company can be a valuable milestone in the portfolio of another, or serve as the base for founding a new company around it.[22] If a company cannot internally benefit from its innovations, others might be able to. In that way, OI creates a platform for transferring innovation efforts to where they would have the largest economic contribution.[23]

2.1.2 How firms open their innovation processes

Opening up ones business means to be involved in different types of collaborations along the value chain of innovation. The value chain presents OI as a sequential process with three phases: idea generation, idea development, and diffusion of developed concepts.[24] Furthermore, across these phases management should perform some critical tasks. When reviewing and analysing OI operations managers need guidance how to optimise their decision-making. Therefore, Gene Slowinski developed several key questions in the "Want, Find, Get, Manage" approach, which breaks down OI into four stages and aims to uncover good managerial practices that are well-established and market-proven in a wide range of business environments.[25]

The starting point for firms is the question: What do we want in order to meet our growth objectives? This defines the "want" of the firm and leads to the next step of finding the needed asset, which can be internal or external. If the asset is not available internally, the company should locate it in the outside and take steps to acquire it by engaging in collaborative relationships. Finally, there is the need to manage the created collaborative relationship. These actions construct a lifecycle approach to OI decision-making and management, representing the OI process as a series of interrelated phases.

[22] See Chesbrough, H. (2003), pp. 135-155.
[23] Thanks to an anonymous reviewer for this comment.
[24] See Hansen, M., & Birkinshaw, J. (2007).
[25] See Slowinski, G., & Sagal, M. (2010, September-October).

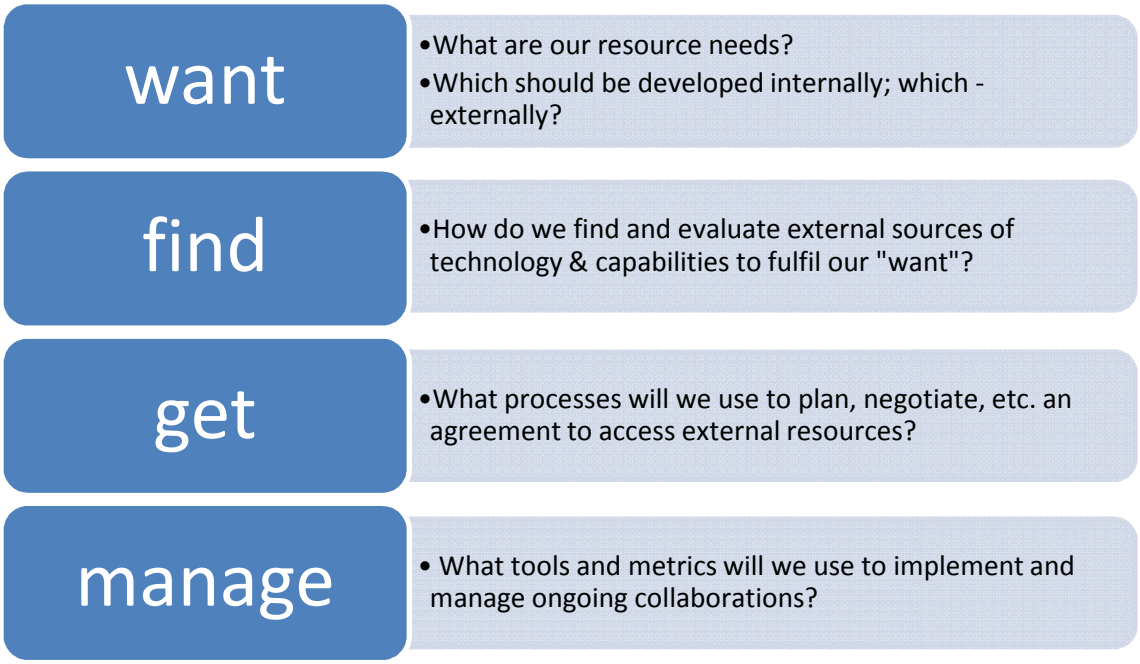

Figure 2: The "Want, Find, Get, Manage" model of Slowinski, G., & Sagal, M. (2010)

In the want phase setting priorities are critical for a successful OI project. At this stage companies may choose to incorporate external thinking into the strategic planning process. Some good practices that guide management throughout this phase are:

- Which unmet customer needs would create more value for the company?
- What internal resources are present to meet these needs?
- What additional/external resources are needed?
- How can the firm acquire additional resources? (purchase, via a partnership)
- Does the firm have the skills to create and manage collaborative relationships with external partners?

The find phase is focused on locating possible sources of external assets, which complement the firm's internal asset portfolio. The choice of a partner is dependent on the firm-specific objectives and strategy. The find phase should be treated as a bilateral process, where each firm considers the pros and cons of a potential partner and is being considered in the same way. Important questions in this phase are:

- How does a firm chooses partners?
- Which are optimal partners?
- Is there an established systematic process for feeding information generated during interactions with potential partners back into the "want" phase?

In the get phase it is important to establish and maintain both the alliance with the external partner and with internal functional groups (R&D, marketing, finance, etc.). A

lack of alignment inside one or both companies is a key reason why alliances fail.[26] Moreover, alignment must be established at the start of the process and maintained throughout the collaboration.

The manage phase begins with coordinating and integrating the partners' resources in order to meet specified objectives. Differences in processes and systems including formal structures and company culture may create stumbling blocks in this process. An important guiding question in this phase is:

- At which stage of the project and how much does the company choose to involve partners?

When a company decides to employ external capabilities, there are several ways in which a partnership is established and collaboration can occur at different phases of the innovation funnel (exploration, development commercialisation). The capacity of a firm that practices OI is as strong as the weakest link in the OI value chain. Therefore, partner selection in the OI process is crucial. Partnering up is done in two main ways: by creating a solution network towards finding answers to specific questions, and by building a discovery network to uncover new ideas within a broader technology or product domain.[27] An OI project may include the creation of partner networks, ideation programs,[28] problem/solver networks, co-creation programs, etc.[29] Customers are considered as the most important source of innovation, followed by competitors and suppliers.[30] In addition, companies rely on cooperation with universities and higher education institutions. The adopted organisational models for opening innovation processes include subcontracting, alliances, licensing, consortia, etc. They are further divided into inbound models (i.e. technological acquisition, where new ideas flow into an organisation) and outbound (i.e. technological commercialisation, where unused technologies can be acquired by external organisations with business models better suited to commercialise a technology). As organisational modes of collaboration, reciprocal license agreements, alliances and joint ventures (JV) are most common.[31] All in all, the type and strategy of collaboration depends on the innovation objectives and the R&D capabilities of the partners.[32]

[26] See Slowinski, G., & Sagal, M. (2010), p. 42.
[27] See Hansen, M., & Birkinshaw, J. (2007), pp. 1-7.
[28] Programs using a creative process of generating, developing, and communicating new ideas.
[29] See Innocentive , p. 4.
[30] See de Massis, A., Lazzarotti, V., Pizzurno, E., & Salzillo, E. (2012), p. 221.
[31] See loc. cit.
[32] See Viskari, S., Salmi, P., & Torkkli, M. (2007), p. 8.

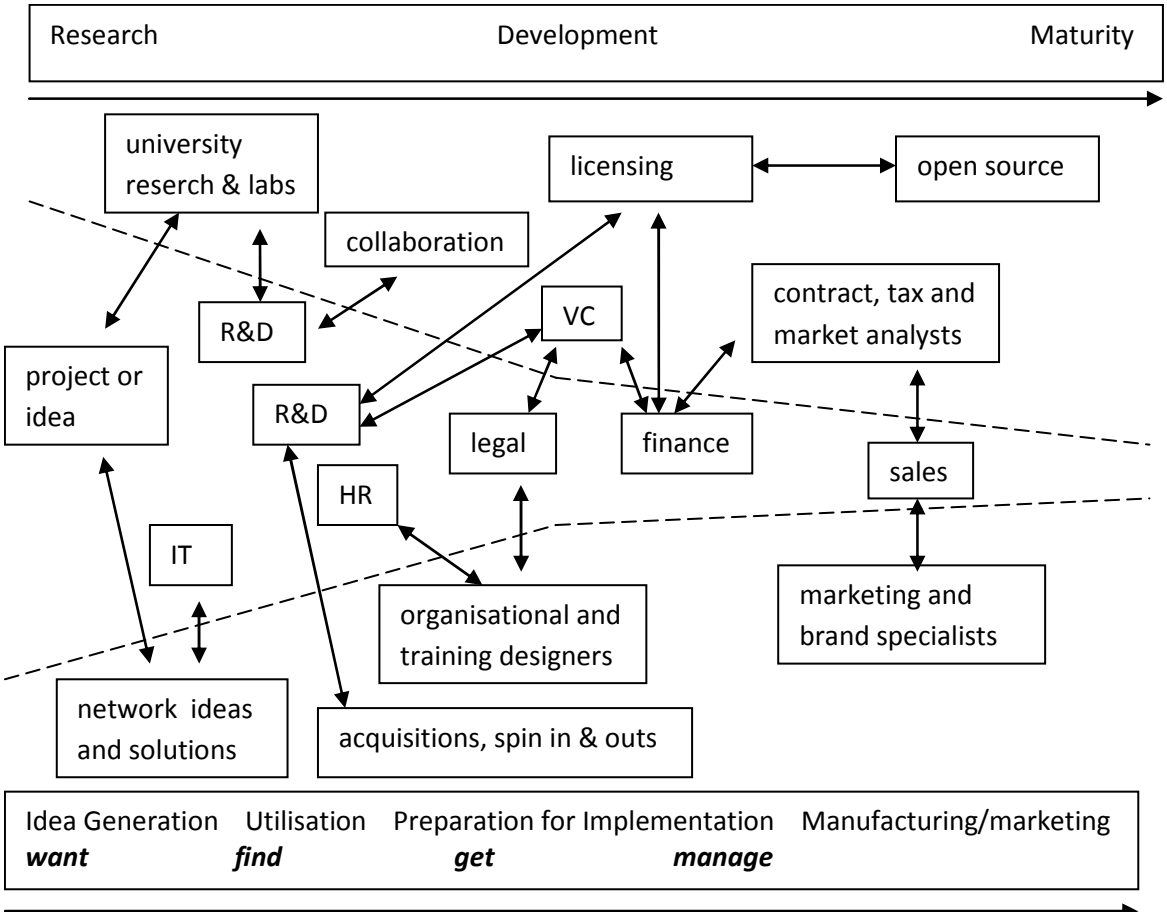

Figure 3: OI collaboration at different phases of the innovation funnel/ value chain

- Licensing (in- and out-licensing) is a fixed-term collaboration. It leads to technology exchange and acquisition. The disadvantages of licensing are limited to contract costs and constraints.
- Strategic alliance is a flexible type of collaboration, which requires low commitment and guarantees new market access. On the downside, strategic alliance can result in unwanted lock-in or knowledge leakages.
- A JV is long-term collaboration in which the parties exchange complementary know-how. It requires a dedicated management to synchronise company cultures.
- Subcontracting with a supplier is a short-term collaboration resulting in reduced costs and risk for both parties, as well as reduced lead time. On the negative side, search costs for a reliable partner can be very high. Also, companies risk product performance and quality if the collaboration turns unsuccessful.

- Consortium with a partner is a collaboration that allows for benefiting from experience and sharing of information, but has the downside of knowledge leakage.
- Being part of a network is another long-term collaboration type offering participants dynamic learning potential and great knowledge exchange at a low cost. The main disadvantage of network participation is the threat of static inefficiencies.[33]

Generally, though actively seeking ideas and collaboration from outside, companies create flexibility in their innovation processes. Flexibility can be generated and utilised at every stage of the innovation funnel. For optimally using OI companies need to define a particular innovation problem, identify relevant knowledge and choose an appropriate integration mechanism. A business model and a partner should be integrated and balanced in accordance with the firm-specific goals and strategy. Therefore, a different type of collaboration is beneficial depending on the innovation problem, strategy and industrial environment.[34]

2.2 Measuring OI

The link between innovation and strategy is fundamental.[35] A corporate strategy of OI dictates sustaining a business model based on invention and coordination overtime. However, there are challenges associated with such a strategy. Ownership of resources generating value should be clear and the ability to prevent others from copying an innovation is needed.[36]

A central question of OI strategists is who captures the created value. Usually Intellectual Property Rights (IPR) allocation guarantees the capturing of the bulk value of OI. Therefore, firms need an underlying architecture of predetermined formal innovation system. The performance and value of a company is based more and more on holding IP and intangibles.[37] As enterprises increasingly depend on external sources of ideas and information, infrastructural arrangements like IPR become more important.

[33] See Tidd, J., Bessant, J., & Pavitt, K. (2005), Ahuja, G. (2000).
[34] See Wallin, M., & von Krogh, G. (2010).
[35] See Morris, L. (2008), p. 4.
[36] See Chesbrough, H., & Appleyard, M. (2007), pp. 58-61.
[37] See Viskari, S., Salmi, P., & Torkkli, M. (2007).

Besides IP, different ways to measure the created value and success of an OI exist. To capture OI, recent studies define three dimensions of OI practices: searching for information, collaboration with business partners, and sourcing of R&D. Success measures of OI include the successful rollout of a product/service, the use of external resources to solve problems not solved in-house and ROI. Companies also, name the ability to foster collaboration among internal employees and general contributions to internal knowledge as important OI success measures.[38] OI project success is a complex measure. However, when looking at the impact of specific dimensions isolated from each other, results are nuanced. On one hand, benefits from OI include and can be measured with the:

- % sales and profit from new products
- Sustainability of revenues
- Product quality and reliability
- Stock value
- Holding IP
- Customer satisfaction and loyalty
- New customers
- Reputation and brand image

On the other hand, OI costs include:

- Total funds invested in ideation and R&D
- Time to market
- Production, distribution and marketing
- Opportunity costs

A further concern is the degree of openness of a firm. The cost of opening up should be carefully aligned to the benefits, and should not exceed them.[39] By engaging in OI firms can defer full commitment to an underlying technology and still maintain the option to expand future technological opportunities. Empirical evidence shows that firms facing a high degree of technological uncertainty are more likely to engage in innovation collaboration.[40]

[38] See Innocentive (2012).
[39] See Chesbrough, H., & Appleyard, M. (2007), p. 71.
[40] See Estrada, I., de la Fuente, G., & Martin-Cruz, N. (2010), pp. 1186-1189.

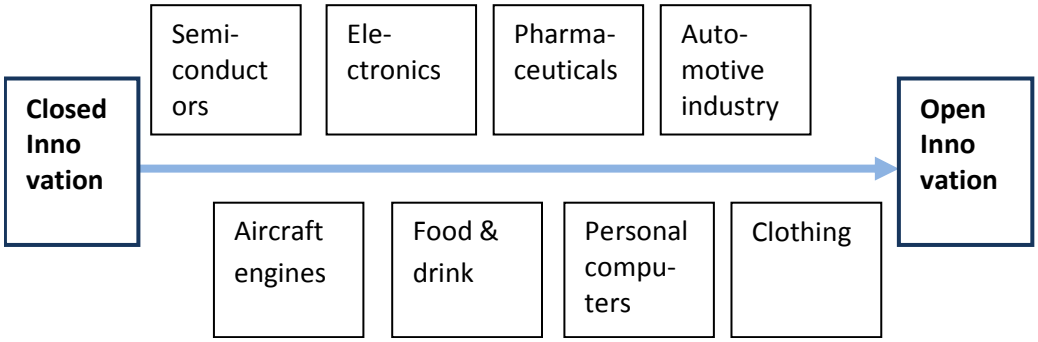

Figure 4: Paul Isherwood, GlaxoSmithKline on industry trends towards OI

Management needs a quantifiable way of representing firm's value to better communicate goals and assess performance. Therefore, measuring innovation emerged as a scientific sphere. Valuing OI is even more complex due to the need of considering all direct and indirect measures of benefits and costs for every party involved. There is no single measure and no one way to capture the benefits of OI. To assess OI one needs to develop useful and predictive measures of the key relationships.[41] Different indicators can be used, and a combination of indicators for both the benefits and the costs presents a better picture of the multifaceted nature and value of an OI project. Moreover, an OI project's value should be measured at every stage of the process.

The importance of innovation is increasing and the capabilities needed to successfully innovate are often not present in one company. Therefore, firms engage in both inside-out and outside-in flow of competences across all aspects of the innovation. OI is a sequential process with the phases of idea generation, development, and diffusion. How firms open their processes depends on the business environment and on company-specific "wants". Finding and integrating partners involves licensing, JVs, strategic alliances, etc. Moreover, the created relationship should be managed and its success measured by aligning benefits to costs of openly innovating. However, simple measures do not encompass the broad dynamic nature of OI. A method of valuation that accounts for flexibility as a major characteristic of OI is needed. One such tool is ROT - a technique that extends its application of corporate finance to decision-making under uncertainty in "real-life" projects.

[41] See NESTA Making Innovation Flourish. (April 2010), p. 6.

3 Real Option Theory

3.1 What is a RO

A RO is the right, but not the obligation to undertake a certain business initiative, such as deferring, abandoning, expanding, staging, or contracting a capital investment project.[42] Investments in physical assets, human capital, and organisational capabilities can be considered as ROs. ROs offer possibilities to acquire or divest assets at a certain price and have an expiration day. Moreover, two types of ROs exist: a call and a put option. A call option provides the buyer with the right to acquire the underlying asset at an exercise price, at any time prior to the expiration date. It involves a second, but optional investment. The net profit on such investment is the difference between the gross profit made and the initial price paid for the call option. A put option, gives the buyer the right to sell the underlying asset at exercise price, at any time prior to the expiration date of the option. In this case the net payoff is the gross payoff minus the initial price paid for put option.[43]

Generally, the logic behind acquiring a RO is that one does not have to make a decision about the complete project at the time of purchasing the option. Investment opportunities modelled by ROs grant their holders the reflective flexibility to invest, wait, or divest in response to new information.[44] Therefore, companies can actively gather information in order to maximise their understanding of each option until the moment of decision-making comes.[45] The value of having an option is the value of having an opportunity.[46] On a company level, ccapital investments are essentially about options, linking current actions to uncertain futures.[47] For example, by investing in a project a company may have the RO of expanding, deferring, or abandoning other projects in the future. Other examples of ROs may be opportunities for R&D, mergers and acquisitions, buying property, licensing IP, etc.[48] Moreover, ROs extensively rely on proactive planning and the ability of management to consider alternatives during strategy formation and implementation.

[42] See Fredberg, T. (2007), p. 72.
[43] See Kang, Y. (2007), p. 27.
[44] See Leslie, K., & Michaels, M. P. (1997), p. 7.
[45] See Miller, K..D, Waller, H.G (2003), p. 97.
[46] See Fredberg, T. (2007), p. 73.
[47] See Adner, R., & Levinthal, D. (2004), p. 74.
[48] See Kang, Y. (2007), p. 28.

Advantages to Net Present Value

NPV assumes a predetermined path of investment when it comes to implementing future choices. Thus, one advantage of ROs over NPV is the possibility of staged investments, particularly true and applicable in dynamic processes.[49] Another obstacle that the application of NPV encounters is the estimate of opportunity cost of capital. Additionally, continuous relationship of investments and inter-project flexibility is not accounted for.[50] ROs have the advantage of generating potential value associated with preserving flexibility in uncertainty.[51] RO analysis values flexibility, which can limit the downside of risk by active management deferring sunk investments and creating value.[52] Other strengths of ROs include quantitative rigor and timing. Option pricing emphasises the potential value of projects, not only the present value. NPV does not take managerial decisions into account, and therefore does not value investments with high uncertainty well. The result is that NPV analysis tends to justify only projects that are more conservative, where the investment amount and timing is established, and the near-term outcome is more certain.[53] Therefore, "... the NPV rule is not sufficient. To make intelligent investment choices, managers need to consider the value of keeping their options open."[54]

Advantages to traditional Decision Trees:

Some of the problems faced by NPV are solved by the use of Decision Tree Analysis (DTA). DTA incorporates managerial choice and models multiple possible paths that the investment can take. However, such type of analysis has the disadvantage of becoming very complex.[55] Including many variables for a realistic analysis complicates the use of DTA. Another downside of DTA is discounting future CFs in consequent decision tree nods – a problem not present in NPV analysis. Therefore, a suitable method to tackle the shortcomings of both NPV and DTA is the RO valuation method, which is theoretically the most advanced tool for valuation of uncertainty and managerial flexibility.[56] ROs approach has a powerful ability to quantify flexible options.[57] Another general advantage of ROs is that by purchasing them a firm ensures

[49] For example innovation processes.
[50] See Kang, Y. (2007), p. 23.
[51] See Miller, K..D, Waller, H.G (2003), p. 98, Leslie, K., & Michaels, M. P. (1997), p. 10.
[52] See Miller, K..D, Waller, H.G (2003), p. 98.
[53] See Mathews, S. (2009), p. 34.
[54] Dixit, A., Pindyck, R. (1995).
[55] See Wouters, M., Roorda, B., & Gal, R. (2011), p. 38.
[56] See Kang, Y. (2007), p. 6.
[57] See loc. cit., p. 74.

its access to certain capabilities in the future, while being exposed to a small amount of risk.[58]

Disadvantages

There are some limitations to the application of ROs. One weakness is the difficulty of correctly valuing in practice the inputs for a RO model; sometimes no direct proxies exist.[59] The practical use of ROs is limited because of the complicated calculations and restricting, but necessary assumptions. A RO offers the possibility to include a sophisticated number of variables and a large number of stages, which can lead to quick complications of calculations, even expanding the option to absurdity. Also, often the assumptions of the models are violated in real life.[60] Moreover, sometimes, managers lack experience and motivation and companies lack systems to support RO analysis.

3.2 Different ROs

Investment decisions in companies reflect the management's responsibility to choose optimally. One type of uncertainty that needs to be resolved in capital investment is the project's scope. There is also uncertainty when and how business conditions will eventuate, which is reflected in the timing flexibility of a project. Moreover, the options which project to exercise: namely, which projects are profitable at the time of initiation and which are likely to become profitable overtime. Management also has flexibility over which product or process to be manufactured and used. In short, ROs represent the management's flexibility in choosing project's parameters like type, size and time of execution. Different types of ROs exist to reflect this flexibility:[61]

- *Pilot option*

The option *to explore or pilot* a project is a RO that allows the implementation of an innovative idea into a prototype with expected costs and payoffs. The pilot option represents the flexibility management has as to *when to start a project*.

- *Growth option*

Growth options provide companies with future investment possibilities. They build flexibility in operations by *increasing the capacity of an existing project* in response to environmental and future events. Growth options allow companies to seize upcoming

[58] See Estrada, I., de la Fuente, G., & Martin-Cruz, N. (2010), p. 1187.
[59] See Copeland, T., & Tufano, P. (2004), p. 2.
[60] See Fredberg, T. (2007), p. 74.
[61] See Kester 1984 as quoted by O'Brien, J., Folta, T., & Johnson, D. (2003), p. 517.

opportunities by leveraging on strengths of the initial project and take the form of acquisitions, partnerships, JVs, and direct investments.

- *The option to defer*

The future value of an option is always greater than the value it would have if it were exercised immediately.[62] All else being equal, one would always prefer to pay later than sooner to earn the time value of money on the deferred expenditure. Moreover, while one is waiting, the environment can change and one can learn more about expected outcomes. Therefore, it is valuable to be able to postpone an investment. The opportunity to wait, gain more information and only then make an optimal choice is reflected in the option to defer a project.[63]

The logic behind a defer option is that if an asset value goes up, one can still acquire it by making the investment (exercising the option). If the asset value has gone down, one might decide not to acquire it: by waiting, a poor investment can be avoided. Generally, the variance of how much things can change while waiting depends on how long one can afford to wait. The option to defer is basically a *trade-off between risk and return*. Investing immediately gives the company earlier less discounted revenues, while waiting might resolve some uncertainty about the market. An option to defer is more valuable if the project outcome is highly uncertain and the investment is irreversible.[64]

- *Option to alter scale*

Options to alter scale incorporate the management's ability *to change the existing scale of a project according to market fluctuations*. When initial activities of a company prove successful, having the possibility to expand operations to other countries, clients or products is valuable. When excess demand is expected, a company may build new production facilities to incur additional revenues. Conversely, production capacities should be constructed and organised in a way that allows partial shutdowns in periods of low demand. Moreover, testing a new market with a scout product and expanding if the test proves successful is another example of expand RO.[65] These options are most valuable in cyclical industries like consumer goods and in businesses with considerable uncertainty about expected future demand.

[62] See Black, F., & Scholes, M. (1973), p. 646.
[63] See Luehrman, T. (1998 a), p. 92.
[64] See Bogdan, B., & Villiger, R. (2010), p. 38.
[65] See loc. cit.

- *The option to abandon or license*

Investments are at least partially sunk or irreversible.[66] However, the decision to continue a project is not the only alternative in front of a company's management. Upon additional information on a project, management can decide to abandon it. The option to abandon a project and terminate all costs associated with it, apart from sunk costs is a valuable option for companies in fast-changing business environments. There also exists the option to license the technology and infrastructure of a project. This option allows the recovery of sunk investment costs. A company that finds a breech between its core economic and market interests and the potential of a project may out-license it to a company that values it higher. In this way, a more optimal distribution of resources is present. Alternatively, one can in-license technologies developed elsewhere that complement a firm's project portfolio. In general, licensing *allows resources and projects to be acquired and developed by the company that values them the highest*.

- *The option to switch inputs*

Switch options reflect a firm's *willingness to pay a certain premium for having the opportunity to change* between production processes, inputs and outputs. Switch options exist due to flexibility of hindsight learning. An operating regime more suitable than the initially planned may exist and the option to switch to it proves a valuable opportunity for any firm. Switch options built the flexibility to accommodate foreseeable, but uncommitted changes.[67]

- *The option to stage investment*

The option to stage investment is a *strategic option relating to the project life and timing* of execution. The exercise of an option on each stage is based on a reassessment of the costs and benefits of completing that stage at the time it is reached. In an investment project each stage represents an option on the value of the subsequent stage, i.e. management has the right, but not the obligation to continue into the next stage. At every stage of a project the company is compounding its options to proceed or abandon the execution of the subsequent stage if uncertainties get resolved. Therefore, there is flexibility built from staged project execution.[68]

[66] See O'Brien, J., Folta, T., & Johnson, D. (2003), p. 518.
[67] See Gil, N. (2007), p. 990.
[68] See loc. cit.

- *Compound options*

Investment projects usually face compound or sequential options. These involve two or more of the above, where the values of separate options interact.[69]

Moreover, options differ in their relation to a project. The RO to expand or alter scale and the option to switch inputs relate to the size of a project. Options relating to project's life and timing are pilot, growth, defer, abandon or license, and stage investment options. Generally, a company possesses more than one RO on a project and good decision-makers use as many options as possible. Therefore, management plays an important role in spotting, valuing, developing and exercising the right ROs.

3.3 Valuing ROs

A RO exists and has value as long as there is time, uncertainty, and potential value in the project, creating flexibility of operations. However, holding a RO open entails both organisational and financial maintenance costs[70] - making flexibility costly to manage and maintain.[71] For valuing flexibility in a RO framework one uses the option value metrics of the Black-Scholes formula, used to calculate the Present Value (PV) of the expected option payoff.[72]

$C\ (S,t) = \mathrm{N(d1)S} - \mathrm{N\ (d2)Ke}^{-r(T-t)}$

$P\ (S,t) = \mathrm{Ke}^{-r(T-t)} - \mathrm{S} + \ \mathrm{C\ (S,t)}$

The value of a call option $\mathrm{C\ (S,t)}$ depends on the value of the underlying asset (S) and time (t). It is equivalent to the present value of the expected asset price at expiration using the risk-free rate $(\mathrm{N(d1)S})$, minus the probability that the call will be exercised assuming that the asset drift[73] is the risk-free rate $(\mathrm{N\ (d2)})$, times the strike price multiplied by Euler's number to the power of the risk free rate times the time to maturity $(\mathrm{Ke}^{-r(T-t)})$. The value of a put option $P\ (S,t)$ also depends on the value of the underlying asset and time. It is equal to the strike price multiplied by Euler's number to the power of the risk free rate times the time to maturity $(\mathrm{Ke}^{-r(T-t)})$, minus the value of the underlying asset (S), plus the value of a respective call option $(\mathrm{C\ (S,t)})$.

[69] See Zhang, X., & Zeng, P. (2007), pp. 23-24.
[70] See Garud & Nayyar, 1994 as quoted by Adner, R., & Levinthal, D. (2004), p. 80.
[71] See Driouchil, T., & Bennett, D. (2012), p. 40.
[72] See Black, F., & Scholes, M. (1973).
[73] The average rate of increase per unit of time.

The following six variables are the general value drivers of a RO.

- Underlying asset value (S)

The underlying asset value is the market estimate of the PV of all future Cash Flows (CFs) associated with the underlying asset of the option. The price of an option depends on the extent to which the innovation offers the firm a positive spillover. Also, the earlier the successful market entry of an innovation, the lower the price of an option.[74]

- Exercise price (X)

The exercise price is the expenditure necessary to acquire the project's asset. It is the real-market equivalent of the PV of all the fixed costs expected over the lifetime of the investment opportunity.

- Uncertainty (σ)

Uncertainty measures the riskiness of the asset, associated with unpredictability of future price movements. It is the standard deviation of the growth rate of the value of future cash inflows. Uncertainty involves variables that are unknown and changing, but will become known and resolved through the passage of time and events.[75] Generally, high-variance assets are riskier than low-variance assets due to the higher probability of resulting outcomes associated with more risk.[76]

- Time to expiry (t)

The time to expiry is the length of time for which a decision can be deferred, namely the period for which the investment opportunity is valid.

- Dividends (δ)

In ROs the dividends are the incurred costs to preserve the option, or the CFs lost to competitors with earlier market entry.

- Risk-free rate of return (r)

The risk-free interest rate measures the time-value of money. It represents the interest that an investor would expect from an absolutely risk-free investment over a given period of time with regard to both financial and ROs.[77] With the risk-free interest rate actual probabilities are converted into risk-neutral and used to discount future CFs.

[74] See McGrath, R. (1997), p. 989.
[75] See Mun, J. (2006), p. 15.
[76] See Luehrman, T. (1998 b), p. 6.
[77] See Leslie, K., & Michaels, M. P. (1997), p. 9.

Luehrman (1998 a) applies option space to strategy, which is seen as a series of options, rather than a series of static CFs. Option space is a framework within which design choices may be discriminated and is defined by two option-value metrics (value-to-cost and volatility).[78] This thesis uses the same two metrics, but extends the underlying factors affecting the key variables in the model (underlying asset value, exercise price, time to expiration, standard deviation, and risk free rate of return). The flexibility is incorporated in the volatility metric, which measures how much things can change before an investment decision has to be made.[79]

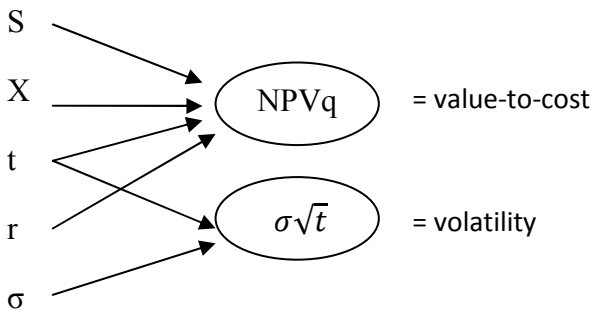

Figure 5: Linking Black-Scholes variables to option value metrics of Luehrman

Luehrman extends the two options of conventional capital budgeting: invest and do not invest.[80] According to its value metrics every undertaking can be classified in one of the six regions, which are valid at each phase of the innovation process. One can choose to invest in a project now, maybe now, probably later, maybe later, probably never, and never.[81] These regions are used to pinpoint where a project is now and how it can move to a region with better prospects. Managers aim to make a correct assessment and relocate projects by making use of timing flexibility. As time to make a decision runs out, the value metrics decrease, so does the flexibility and the option loses its lure.

[78] See Harrison, M.D. (1992), pp. 150-156.
[79] See Luehrman, T. (1998 a), p. 91.
[80] See Koussis, N., Martzoukos, S., & Trigeorgis, L. (2006), p. 31; Fredberg, T. (2007), p. 74.
[81] See Luehrman, T. (1998 a), p. 93.

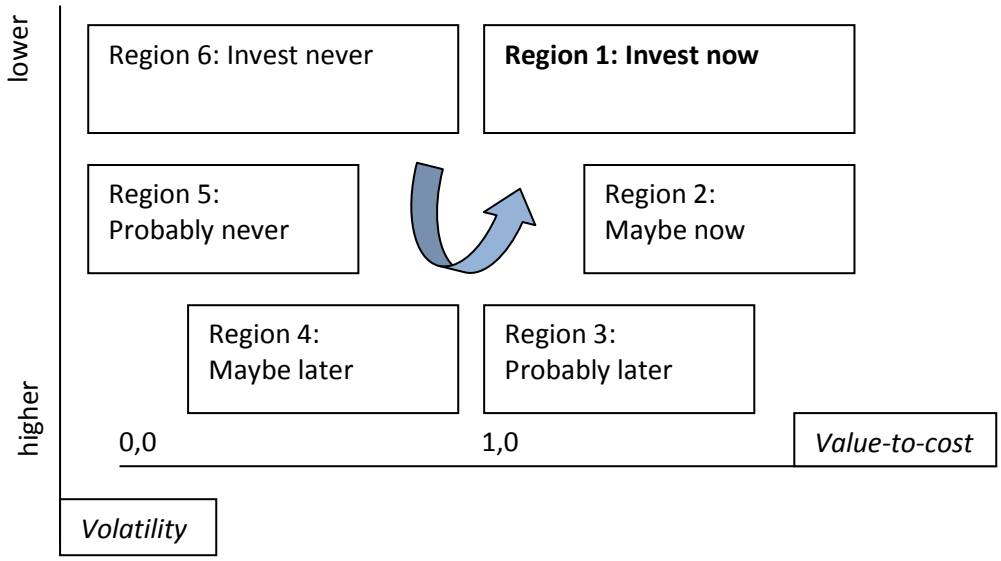

Figure 6: "The tomato garden" Luehrman (1998 a)

Today, there is a multitude of different explanations and forms of ROs that are a root for disagreement and hinder a broader use of the method.[82] This is partly due to the treatment of ROs like financial options. Despite of some shortcomings in the method, scientific research on ROs extensively uses the model proposed by Black and Scholes. The option-value metrics construct a generalising framework for valuing investment projects and widely reflect available data on prices, asset value and uncertainties.

3.4 Managing ROs proactively: pulling ROs levers

Contrary to what Adner & Levinthal (2004) state in their publication, RO investors can take steps and make intrinsic characteristics of the underlying asset more attractive. However, firms can only exploit flexibility in their operations if they have developed systems, competences and managerial capabilities to exercise ROs.[83] ROs decision-making as used by Driouchi & Bennet (2012) describes the set of management decisions that assess flexibility and infer that organisational and managerial factors play a role in implementing a firm's portfolio of ROs. Management should perform regular, formal reviews to obtain information on all sources of uncertainty, in order to target flexibility to where it is needed. Managers can proactively influence the value of a company's options by pulling different RO levers. Which RO levers a company can and should pull in order to increase the value of its options is a question addressed in Leslie, K., & Michaels, M. P. (1997). A sensitivity analysis on the six levers shows potential

[82] See Bogdan, B., & Villiger, R. (2010), p. 7.
[83] See Driouchil, T., & Bennett, D. (2012), p. 54.

economic priorities and identify the levers that should be pulled. Moreover, there are some levers that management can pull more easily than others, depending on both the internal and environmental constartints on the company.[84]

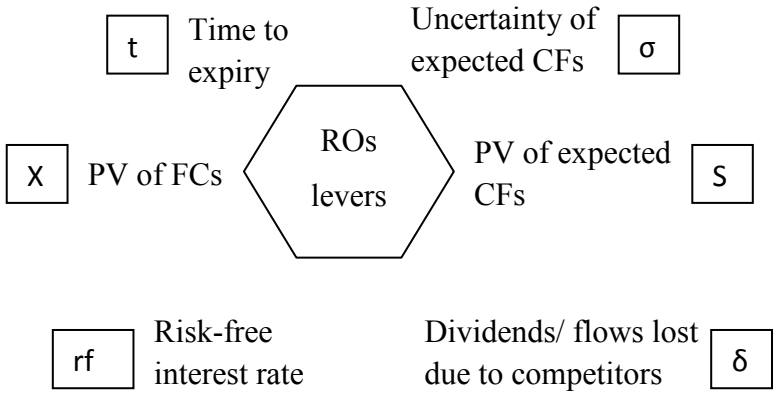

Figure 7: Real Option Levers - Leslie, K., & Michaels, M. P. (1997)

Lever 1: Increase the PV of expected operating cash inflows

Managers can achieve that by developing specific marketing strategies, or contracting low-cost suppliers. These strategies would lead to higher revenues as an end effect: by raising the price earned, by producing more, or by generating sequential business opportunities. Past empirical research suggests that the most sensitive RO lever is changing the PV of an innovation project.[85]

Lever 2: Reduce the PV of expected operating cash outflows

Such a reduction is possible by leveraging economies of scale and/or scope. A company is able to achieve that in cooperation with others, and also leverage economies of learning.

Lever 3: Increase the uncertainty of expected CFs

When management increases the uncertainty of both expected cash in- and outflows, the value of the option raises due to the increased value of flexibility. Increasing the uncertainty is done by extending one's opportunities to related markets, by encouraging complementary products, and bundling of products. Moreover, during uncertain times or in uncertain situations having the option to adjust to changes is more valuable than the option of a stable environment.[86]

[84] See Leslie, K., & Michaels, M. P. (1997), p. 12.
[85] See loc.cit., p. 19.
[86] See Fredberg, T. (2007), p. 74.

Lever 4: Extend the opportunity's duration

Extending the opportunity duration increases the total uncertainty of an option and therefore increases the value of that option. A company can prolong its option by holding a technology lead, by signalling ability to exercise, and by maintaining regulatory barriers.

Lever 5: Reduce the value lost by waiting to exercise

The value lost to competitors can be reduced by discouraging them from exercising a RO. Thus, management can reduce the value lost to waiting by creating barriers for competitors, locking up key resources and lobbying for regulatory constraints.

Lever 6: Increase the risk-free interest rate

This is the one lever management cannot subject to proactive flexibility. The market risk-free interest rate cannot be influenced by any party, and the only thing that can be undertaken is to monitor its changes. An anticipated increase in the risk-free rate would reduce the PV of an option's exercise price and raise its value.[87]

Usually, increased uncertainty leads to higher asset value if managers recognise and use options to flexibly respond to changing conditions and events in the market.[88] There are numerous ways to build flexibility within a company: e.g. by continuous investment in human capital and physical resources. Thus, one can design flexible organisational structures, processes and inter-firm relationships.[89] Generally, managers should adopt a company-tailored, end-to-end approach of innovating.[90]

ROs give the right, but not the obligation of management to undertake a certain initiative. Different ROs exist to reflect various opportunities of companies to start, develop, abandon, license a project, change its scale or inputs. Managers make use of staged investment and compound flexibility in operations that result from recognising the value of ROs. And ROs are valuable as long as there is time and uncertainty present. Managers use company structures and exercise decisions trying to increase the volatility and value-to-cost of options, thus, moving them to more favourable regions of investment. This is achieved by pulling RO levers. The five levers that management has control over are key in integrating the literature strands of OI and ROT in the next

[87] See Leslie, K., & Michaels, M. P. (1997), pp. 12-14.
[88] See Kang, Y. (2007), p. 32.
[89] See Miller, K.D, Waller, H.G (2003), p. 103.
[90] See Hansen, M., & Birkinshaw, J. (2007), p. 2.

chapter. Besides on a theoretical level, RO levers will be used in the empirical analysis in order to integrate theories and practice in chapter *6*.

4 Flexibility as a link between OI and ROT

4.1 Identifying and valuing flexibility in OI projects

A lot of uncertainty is involved when developing and implementing an innovation. Thus, there is the need to incorporate risk in a predictive model. Estimating such type of uncertainty is a suitable application for ROT, because ROs account for irreversibility, uncertainty, and the choice of timing in the investment decisions.[91] Furthermore, corporate strategy of OI dictates sustaining a business model based on invention and coordination overtime.[92] According to Fredberg (2007) it can be viewed as the exercise of a number of options on the future, because any "development process should be structured as staged investments to allow for flexibility and monitoring of the created options..."[93] Scholars have started to think of innovation investments as options, rendering the application of ROs to OI undertakings a valid approach of opportunities' valuation. A combination of these two strands of literature is only intuitive and can be done along any of the numerous linking variables. Vanhaberbeke, et al. (2008) have conducted an explorative investigation that offers scholars initial ideas on how ROT can strengthen the theoretical foundation of the OI literature. The authors argue that the benefits of extended flexibility that are characteristic of OI can be materialised through the presence of ROs.[94] The underline is: OI is a strategy and strategy is built of ROs.

In a continuously changing environment like the stage of OI, flexibility is highly valued and is guaranteed by the sequential nature of option investment.[95] When applied to OI, ROs may increase project value by allowing better managerial decision-making.[96] Project managers can and should make use of flexibility factors in order to increase the value of ROs. The analysis of OI investment should move "away from a world of wait and see to a world of act and see."[97] Flexibility grants a company the possibility to adapt and change when new knowledge of the surrounding system is gained by allowing reversible alternatives embedded in investments and operations.[98]

Different types of flexibility exist at all stages of the OI process. One type of flexibility is *operational flexibility* within a project. It allows managers to revise a project: they

[91] See Dixit, A., Pindyck, R. (1995).
[92] See Chesbrough, H., & Appleyard, M. (2007), p. 58.
[93] Fredberg, T. (2007), p. 72.
[94] See Vanhaverbeke, W., van de Vrande, V., & Chesbrough, H. (2008), p. 252.
[95] See Adner, R., & Levinthal, D. (2004), p. 78.
[96] See Bollen, N. (1999), p. 1.
[97] Adner, R., & Levinthal, D. (2004). p. 76.
[98] See Fredberg, T. (2007), p. 81.

have the ability to abandon, contract, invest, or delay the project when needed. In contrast, *strategic flexibility* is present between a series of interdependent contingent investments.[99] Moreover, when incorporating RO's flexibility in OI analysis one can also distinguish between reactive and proactive flexibility. The *reactive flexibility* of an option holder allows them to respond to environmental changes in order to maximise a payoff. *Proactive flexibility* allows the option holder to increase the value of an option once acquired. This is possible due to the nature of ROs, which represent real business situations with limited number of interacting parties that can influence the option value. The most common RO is the option to *delay an investment* project until more information is available.[100] Such type of option, when viewed in an OI project, has the flexibility associated with interactions with competitors and its potential applications include licenses or patents. Another RO in an OI setting is the possibility to *abandon a project* before its planned end. This can be realised by the flexible option to sell this project to a secondary market and realise salvage value. Mainly, that is used in the capital-intensive industries where companies prefer to abandon projects not in line with their main business. These ideas or innovation developments at an early stage are sold to other companies, or even new firms are formed around single projects. Such flexibility allows for recovering sunk costs and lets the selling firm maintain a focused strategy. Furthermore, waste of resources is minimised as the idea or project is used by another firm that values it higher and implements it in an alternative market or industry. In this way, the flexibility provided by an abandonment RO is essential in limiting the downside risk.[101] A further operational flexibility in OI is the *opportunity to expand or contract*. By increasing or decreasing the production capacity of an initial investment against follow-up investments a firm can make use of the cycles in an industry. Other uses of that option are associated with entry into markets with uncertain future demand. Opening up one's innovation processes entails changing or substituting products, inputs, or geographical location of production based on relative cost. This is matched by the RO to *switch.* The flexibility to scale back or exit is another essential RO in the process of OI. Such options are the rent of plants and equipment, substituting one method of production with another, temporary workers, exit provisions in contracts, etc. In general, by investing in flexibility, a company can reduce the cost of switching its

[99] See Kang, Y. (2007), p. 33.
[100] See loc. cit., p. 36.
[101] See Adner, R., & Levinthal, D. (2004), p. 75.

strategy.[102] Often, a *compound flexibility option* exists. It is a combination of at least two operational options and presents at least two sources of uncertainty in firm's operations.[103] In reality, most OI investment decisions are represented by compound options due to the several correlated sources of uncertainty involved in associated projects.[104]

The RO's value of an OI project is a function of its underlying asset value, the exercise price, the standard deviation of risk, time, dividends and the risk-free rate of return.

$V(RO) = f(S+, X-, \sigma+, t+, \delta-, r+)$

The value of a RO is higher, the higher the project value (S) or the lower the capital expenditures (X). Also, higher risk-free interest rates (r) or longer time to expiration (t) increases the value of a call RO. The higher the dividends, the lower the value of an option.[105] Moreover, uncertainty can be a source of value for any firm engaging in OI if options are recognised and optimally exercised by management; and time is the primary driver that decreases uncertainty.[106] Flexibility stems from running a sensitivity analysis on the underlying variables of a project and allows management to create value by pulling the RO levers outlined in *Figure 7.*

Any investment has a time dimension between the making and the implementation of the decision. During that time the value of the investment changes.[107] In the early phase of OI the focus should be on improving the probabilities for uncertainties and deliverables that have the strongest potential effect on the value of the RO. In later stages, the emphasis is shifted to uncertainties and scenarios through which the option value will be realised.[108] If operational uncertainty is resolved before decisions are made and costs or revenues are incurred, flexibility can be applied to protect the project against a downside. In this case, more uncertainty enhances the option value of managerial flexibility. However, if operational uncertainty is resolved after decisions are made, or if it reduces the probability that flexibility is useful, more variability reduces the ability to respond, thus diminishing the option value.

In general, flexibility does not offer benefits in a certain environment. What is more, the presence of flexibility alone does not bring much, it has to be perceived, understood and

[102] See Miller, K.D, Waller, H.G (2003), p. 97.
[103] See Kang, Y. (2007), p. 35.
[104] See loc. cit., p. 56.
[105] See Luehrman, T. (1998 b).
[106] See Kang, Y. (2007), p. 77.
[107] See Kogut, B., & Kulatilaka, N. (2001), p. 747.
[108] See Wouters, M., Roorda, B., & Gal, R. (2011), p. 44.

used. Therefore, management needs to associate the value of OI projects to flexibility where at different stages flexibility stems from different opportunities.[109] Through an option-based view on firm's strategic planning and resource exploration and exploitation management can embed flexibility in its decision-making. That would create a systematic capability of taking advantage from uncertainty, structure project management and mitigate the downside risk of operations.[110]

4.2 Constructing a model

An analysis on company level should start up with weighing the pros and cons of whether an OI approach can be adopted. Then, the company needs to determine how to set up the openness and find a matching business model. The next step for every firm should be to get familiar with the obstacles and advantages it faces while implementing an OI approach. Lastly, companies need to understand the value of ROs and be able to recognise and use them by tracing flexibility points in operations. Even more company capabilities are needed to create these options by generating flexibility and that is the utmost goal for managers - to uncover decisions and paths of operation that create value.

Publications on many companies famous for openly innovating is used to create a general framework of practical key managerial decisions that help or hinder the successful application of OI in a project setting. Both successful and failed innovation processes and the reasons behind are reviewed in order to complete the picture of do and don'ts in opening up ones business.[111] A table is created to list *RO* levers that management is able to most easily pull at each stage of an OI project. Although, these managerial actions are gathered form practical research publications, *Table 1* serves as a theoretical backbone against which three case studies will be compared in the empirical justification in chapter *6*.

At the **idea generation** stage of an OI project a company can choose innovation ideas from different sources. Ideas come from both internal and external parties as the firm scans the business environment and screens ideas from investors, start-ups, partners, customers, and scientific research labs. Uncertainty at this stage stems from the choice

[109] See Lint, O., & Pennings, E. (2001), p. 166.
[110] See Driouchil, T., & Bennett, D. (2012), p. 40.
[111] See A2 in the appendix.

of a partner, the degree of partner involvement, and the presence of a formal innovation strategy in the firm. Flexibility, therefore, comes from collaboration, which increases the underlying asset value of an OI project. In generating ideas and solutions choosing a partner with similar company culture and compatibility of vision and mission results in less uncertainty (σ). However, breakthrough ideas involve a lot of uncertainty and usually an unconventional partner. A very involved partner accounts for better quality of generated ideas and increases the potential value of a project.[112] Generally, the presence of a formal innovation firm strategy reduces σ and time (t) in cooperations. Furthermore, institutional and governmental support at the ideation phase of OI allows for more time until a decision on partnering up and the valuation of ideas is made.[113] At the idea generation stage asset value (S) increases because companies get access to variability: new ideas, technologies and approaches used by partners. Cooperative research projects increase the value of ideas and create solutions otherwise not possible. A high frequency of collaboration increases both the exercise price (X) and the S. Furthermore, a company spends time and effort to search for and contract a reliable partner. There are expenses on both sides for communicating and absorbing the knowledge of partners. All these increase X. Cross-functional collaboration in generating ideas increases both the S and X of a project. If generated ideas change in pace with market needs there is a combined positive effect on collaboration and on the value of the project.

At the idea generation stage of an OI project partnering up with venture capitalists decreases X and σ. Leveraging external resources does the same. When generating ideas, a company should align its current capabilities to its aimed for OI strategy in order to decrease X and increase S. In this stage it is particularly important to involve a senior-level champion in order to decrease X and t. When involving external parties, promoting linkages like forums, seminars, etc. is important to reduce t. Lack of ability to build partner trust in the generation of ideas leads to longer t and higher X. Considering firsthand information about business and technological trends increases S and decreases X, t and σ.[114]

Usually, the ROs associated with this stage of an OI project are pilot ROs. Abandon, license and stage investment options are also present. The RO levers that management

[112] See Dyer, J., Kale, P., & Singh, H. (2004)
[113] See McGrath, R. (1997), p. 979.
[114] See Estrada, I., de la Fuente, G., & Martin-Cruz, N. (2010), p. 1188; Chesbrough, H. (2003), p. 128.

can most easily and efficiently pull at this stage in order to influence the value of the options present are *Lever 3* and *4.*[115]

In the **utilisation of ideas** stage compatibility of company cultures has positive effect on S and decreases the price of the partnership; so does technical feasibility in executing an OI project. In this phase monitoring of potential customers and the market leads to higher X and t and lower σ. Both S and X increase hand in hand with the number of filed and granted patents. Generally, the cost of projects increases with higher number of ideas going to the next stage, regardless of synergies in execution.

Setting up internal venture capital group to commercialise ventures out of partnerships and research labs increases both the S and the X of OI projects. Hindering formation of spin-offs has a negative effect on the utilisation of ideas. Early investments that have to be abandoned can be valuable to other business units within the same company or other companies, leading to no loss of S. An initial idea can be modified (change of application, target market, etc.) and in- or out-licensed.[116] Moreover, enough internal work should be done in a company so that external information can be absorbed and put to value. Contextual skills should be supported and that also increases both S and X. Reinventing fewer wheels and building on the research of others decreases the X of a project. Establishing a systematic process of capturing best ideas for utilisation decreases X and the σ of an OI undertaking. Generally, OI and business goals should be aligned in order to account for higher S, lower X and lower σ of a project. Devoted senior management has the same effect. Capturing good ideas effectively by creating a solution that benefits all cooperating parties in the OI is crucial for higher S, lower X and t. Getting over the "not invented here"-syndrome lowers the cost of research and the exercise price of an underlying RO. There is also the need to manage the whole portfolio of OI projects in order to reduce σ.[117]

ROs associated with decisions at the utilisation of ideas stage are mainly growth, defer and license options. The corresponding RO levers that should be pulled in order to increase the value of a RO at this stage are *Lever 1, 4, and 5.*

In the **preparation for implementation** stage the development and testing of an innovation is done. At this stage a higher number of patents translates into higher OI project S and X. Prototyping increases X and t of the RO on the project and decreases σ.

[115] See Figure 7: Real Option Levers - Leslie, K., & Michaels, M. P. (1997).
[116] See Chesbrough, H. (2003).
[117] See Wouters, M., Roorda, B., & Gal, R. (2011).

However, over-engineering decreases S and immensely increases X. Many R&D hours result in higher X and ideally translate into higher S. A strategy focusing on new technologies, including simulation, modelling , virtual reality, data mining and rapid prototyping insures both higher S and X at this stage of a project. High speed of prototyping results in lower t, and higher X. Reliable partners increase S; partners with market influence and reputation decrease σ.[118] Outsourcing standardised work to a long-term partner decreases both σ and t. Offering unused IP outside of the company limits waste of resources and increases the exercise price of the underlying RO. IP protection that becomes legal handcuffs and restricts opportunities decreases X and increases σ. Poor execution of ideas usually leads to failure of innovation and strategy, which has an adverse effect on S and δ, and leads to higher X.[119]

ROs most often present at this stage of OI projects are growth, defer, expand/alter scale, abandon, license and the option to stage investments. Management's actions that create value at the preparation for implementation stage of an OI project relate to RO Levers *1, 2, 3,* and *5.*

At the **manufacturing and marketing** stage there is uncertainty about the completion of the innovation launch. Collaboration with suppliers at this phase means lower X and t. Presence of competition on the market increases σ and decreases t of an OI project.[120] Renting of plants, equipment and temporary workforce increases X, but considerably decreases σ. Changing production methods, inputs, or geographical location based on relative cost decreases X and usually increases S. Monitoring customers increases S and decreases σ. Involving team members from different units of the organisation in the manufacturing and marketing results in higher X - different competences of involved parties is less valuable in this last stage of the OI project. At this stage it is very important that companies help external partners by being specific about company wants in terms of innovativeness. Clearly communicating marketing needs has a negative effect on X and σ. Thinking in terms of one-off deals and not supporting long-run wins leads to lower S. Also, trying to manage the process instead of collaborating with the partner leads to lower S and higher X and σ. The bottom line is value creation: all actions towards OI should lead to creating value for the company by increasing S.[121]

[118] See McGrath, R. (1997), p. 981.
[119] See Chesbrough, H. (2003), p. 110.
[120] See Fredberg, T. (2007), p. 76; Luehrman, T. (1998 a), p. 97.
[121] See the case of LEGO.

Usually the RO associated with this stage of an OI project are: expand or alter scale, abandon, and switch inputs. The corresponding RO levers that management pulls most effectively at the manufacturing and marketing stage are *Lever 1, 2, 3,* and *4.*

Table 1: RO levers that management can most easily pull at each stage of an OI project

OI phase / **RO lever**	OI phase 1: Research - generation & utilisation of ideas	OI phase 2: Development - preparation for implementation	OI phase 3: Maturity - manufacturing & marketing
RO Lever 1: *Increase the PV of expected operating cash inflows*	by cooperating with compatible partners, low-cost suppliers, overcoming the "not invented here"-syndrome, presence of formal innovation strategy	by involving reliable partners, successfully acquiring IP, prototyping, no over-engineering	by supporting long-run wins and not focusing on one-off deals, monitoring of customers
RO Lever 2: *Reduce the PV of expected operating cash outflows*	by systematic capturing of best ideas, reinventing fewer wheels, supporting contextual skills of partners	by leveraging economies of scale, scope & learning, contracting reputable partners, outsourcing standardised work	by collaborating with partners not just managing the relationship, changing production methods based on relative cost, being specific about company wants
RO Lever 3: *Increase the uncertainty of expected CFs*	by actions related to operations, strategies and markets, not partnering with venture capitalists	by encouraging complementary products and bundling	created by presence of competition
RO Lever 4: *Extend the opportunity's duration*	by increasing the time uncertainty of an option, institutional and governmental support		by holding a technology lead, creating barriers for competitors
RO Lever 5: *Reduce the value lost by waiting to exercise*	by systematic capturing of best ideas, creating barriers for competitors, promoting external linkages	by a fast preparation and implementation of the OI project, high speed of prototyping	

Benefits of flexibility present in OI are materialised through reviewing the process under a RO lens. Every OI project has underlying ROs, that are higher, the higher the project value or the lower the capital expenditures. Higher risk-free interest rates and longer time to expiration also increase the value of options. Another source of value is the presence of uncertainty. Reactive and proactive flexibility exist at all stages of the OI process where management decides on exercising ROs. In this way, they create flexibility which stems from pulling the most sensitive RO levers. For different projects, companies, and business environments different practices are valuable in creating flexibility. Therefore, the next chapter will describe the method used in collecting data for empirically backing the model of *4.2.*

5 Methodology

After linking ROT to OI analysis on a theoretical level, my research provides a practical framework. The list of managerial decisions that affect RO levers and create flexibility in an OI project is examined in more detail. The unit of analysis is an innovation project and flexibility points in different projects are analysed to create comparative results.

"There is no one-size-fits-all approach to scenario planning."[122] Environmental, industrial and firm-specific idiosyncrasies affect the planning and decision-making processes within a firm. That is also the case for firms engaging in OI, a process that plays over time. Therefore, case study design is particularly useful.[123] The use of secondary data of this type allows both an in-depth examination of each case and the identification of contingency variables that distinguish each case from the other. Therefore, my research involves data collection through case studies and referencing publications on OI projects within firms from different industry sectors. I focus on three companies that are famous for their OI practices. LEGO Group has successfully implemented customers into their innovation processes; IBM is using aggressive licensing and collaboration; and Nokia is viewed in the light of engaging in strategic alliances. LEGO and IBM are chosen as examples of good managerial decision-making leading to a lucrative engagement in OI projects. The case of Nokia is chosen to show a not so successful approach to openly innovating in a new innovation area - the smartphone market. Choosing to present three different cases, one of them as a negative example of managerial decision-making is to avoid the bias of only studying best practices, which limits the knowledge about challenges regarding OI. Rather than looking at drivers of success only, the study of Nokia focuses on obstacles to successful OI and outlines possible ways to overcome these obstacles.

Many uncertainties exist about technology and the market when it comes to implementing innovation projects and "every company has unique innovation challenges."[124] Therefore, one needs a good understanding of how both environmental and internal uncertainties affect companies' innovation processes and risk.[125] These cases increase one's understanding of how OI works and enable the uncovering of important concepts and phenomena. They also provide us with in-depth understanding

[122] Miller, K.D, Waller, H.G. (2003), p. 95.
[123] See Chiaroni, D., Chiesa, V., & Frattini, F. (2009), p. 37.
[124] Hansen, M., & Birkinshaw, J. (2007), p. 1.
[125] See Miller, K.D, Waller, H.G. (2003), p. 101.

of crucial contextual characteristics for the success or failure of certain practices and managerial decisions.

The chosen cases follow the same framework of representation. First, a general description of each case is provided to introduce the company and its approach to innovation. Then it is shown why this is an example of OI, with reference to the general characteristics of OI discussed in chapter *2*. After that, it is revealed why are there ROs present in this case and a conclusion is drawn as to why ROs and OI can and should be aligned in this particular example. The specific managerial decisions and the created options are compared to the RO levers' checklist provided in *Table 1* in chapter *4.2*. Each case shows how the value of an OI project changes at each stage with managerial actions - what the management did or could have done - if it made use of the presence of flexibility, or if they ignored the opportunity.

6 Empirical illustration of the model

6.1 Case 1: LEGO[126]

LEGO is a famous Danish toy company that created its interlocking blocks in 1949. Since then LEGO has developed a global image and broadened its operations to games, movies, themed amusement parks and is the 5th largest toy maker in the world.[127] LEGO is also one of the first companies that successfully introduced various OI practices.

In 1998 the Danish group has experienced its first financial loss, followed by a historic loss of 188 million Euros in 2003. These acted as a signal and stimulated a fundamental change in the operations of the company. LEGO avoided bankruptcy by opening up its innovation and over the last years the company has tripled its turnover. This achievement is a result of radical changes in the way business is done, but also of new innovation processes and management. Firstly, the culture at LEGO changed, stating the new number one priority: "making money for the company". This change in corporate culture was the first step to introducing OI. Thereafter, a systematic approach was developed: investigating various best practices enabling a more OI process, running pilot projects and experiments.

Dr. Peter Svensson from VINNOVA[128] states that society today is in the middle of a paradigm-shift from customer-centred to user-driven innovation processes.[129] That was also felt and incorporated in the innovation strategy of LEGO. "Consumers of today are intelligent, they are creative and have an opinion...and they expect you to listen."[130] Therefore, a particularly innovative client relationship was established through the creation of Cuusoo - a web-based crowd-sourcing platform where consumers are able to submit and vote for their favourite ideas for new LEGO products. If a submitted idea has more than 10 000 votes it gets reviewed by LEGO specialists to potentially become an official product. If an idea is commercialised, the creator receives up to 1% of the total net sales of the product. When a project passes along to a review and development team the first aspect looked into is if the suggested product would make enough in sales to create a profit for the company. Therefore, a review is performed by a LEGO Jury.

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[126] See Open your innovation blog (16 May 2012); LEGO CUUSOO Blog (22 May 2012); LEGO official webpage; Antorini, Y., Muniz Jr., A., & Askildsen, T. (2012).
[127] Open your innovation Blog (2010, April 1).
[128] A Swedish governmental innovation agency.
[129] See Empirica. (2011, August 26).
[130] Internal LEGO quote.

Another front on which LEGO is opening up is cooperating with artists to create a new type of entertainment for its customer base. LEGO's architectural artist Adam Reed Tucker has helped in the creation of worldwide architectural landmarks through LEGO Architecture Eye. Now fans can build and learn more about famous constructions like the Sydney Opera House, Big Ben, Brandenburger Gate, The Empire State Building, etc. What is more, customers can suggest their favourite monuments form around the world and soon see them as LEGO construction sets. With LEGO Architecture Eye the company is even more deeply engaging its customers into the innovation of its toys, now beyond simple plastic bricks. Moreover, LEGO is engaging in producing programmable construction sets. To keep pace with developments in the toy industry in the digital age LEGO introduced Mindstorms - programmable bricks with sensors allowing customers to build movable designs and toys. For the development of this product LEGO engaged in cooperation with software developers at the Massachusetts Institute of Technology (MIT). However, with less than a month on the market the programmable products were hacked and users started making own unauthorised modifications. LEGO could see that as an IP infringement or as an opportunity. The company took the second stand and in cooperation with its users developed creative designs, improving the product and generated more sales and popularity among fans. The next generation of Mindstorms was even developed by user-designed parts.

Why is this case an OI example? (Refer to Chapter 2)

LEGO has adapted its operations to the changed market conditions and risks. In the digital era it was either opening innovation or fading away in the toy industry. LEGO decided to engage in OI in order to resolve its business challenge that could not be solved internally. The company realised that it cannot continue to successfully innovate in a vacuum and through OI its products will improve and flexibility will rationalise investments.

LEGO chose to open its innovation at the want phase by incorporating customers. Being successful on the market is always dependent on customers' taste. That is why, LEGO chose to involve its fans in the value creation chain of operations by making them the most important source of innovation. LEGO has built a discovery network around its customers' base in order to uncover new ideas in a broader product domain. In this way, LEGO receives information about unmet market needs that would create value. Combining internal and external resources through its customers' network LEGO generates flexibility in its innovation processes. Involving customers in the idea

generation phase of OI is not always a success as most ideas lack industrial functionality; do not meet profit margins, etc. In the case of LEGO and its toy market, involving customers was a triumph that save the company from bankruptcy and opened opportunities for new projects, lines of toys and company growth. Moreover, LEGO has established a systematic process for feeding information generated during interactions with customers back into the want phase of its OI, thus, creating even more opportunities for outlet of customers' creativity. In the get phase LEGO managed to maintain a good alliance with its customers and also keep internal integration of departments. The manage phase begins with coordinating and integrating the partners' resources and for LEGO that is an ongoing process covering all stages of the innovation as the company tries to involve fans as much as possible.

Another central question of OI that LEGO dealt with impeccably is the capturing of created value. LEGO has established a successful IPR framework in which the company becomes a holder of any created IP, but the party with the idea (a customer) receives monetary compensation for their creativity, leaving both sides of the OI project satisfied. In every business nowadays holding IP is an invaluable resource. A good strategy of LEGO is having patents on its building bricks and sets.[131] Parts of different toy systems, as well as the method behind combining them in a set is patented, which does not allow innovative customers of LEGO to create a new toy and profit from that in any way. Therefore, Cuusoo is the perfect outlet of fan creativity, which rewards winning designs of customers and at the same time, protects and expands the IP of LEGO. In the case of Mindstorms, LEGO also made a right choice - instead of suing for IP infringement it chose to cooperate with customers, which resulted in a good relationship and proved profitable in the long-run. These methods have worked for the company, and the success of LEGO is measured by successful rollout of numerous new toy products. Furthermore, the company continues to increase its IP pool and positive brand image.

[131] World Intellectual Property Organization (WIPO), patent search on LEGO AS.

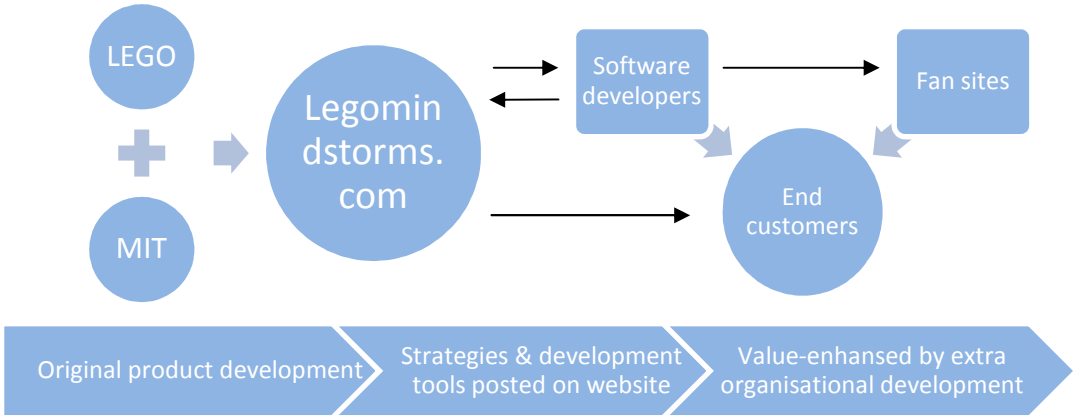

Figure 8: The Mindstorms open source community has accelerated product innovation and turned Legomindstorms into a highly profitable product line

Why are there ROs in this case? (Refer to Chapter 3)

ROs create the opportunity to sell a new product to the market in the future after the development process has been completed.[132] LEGO has created a program to get into a fast and direct contact with users and expand the LEGO play experience. Consequently ROs for LEGO emerge with the posting of an innovative idea on the Cuusoo platform. When a customer submits a design, LEGO has the option to make a decision about the time of project initiation. When an idea receives enough support from customers the option to pilot a project exists. The same logic faces the creation of Architecture Eye and Mindstorms designs.

LEGO has created a call option of acquiring a customer's design at no price at all (maintaining online platforms of communication has negligible cost for LEGO) and a second option to invest in a popular design. For every suggested design LEGO can choose to invest now, maybe now, probably later, maybe later, probably never, and never,[133] depending on the votes and the popularity of the idea among other customers. In this way, the company has involved users at the very first stage of innovation - idea generation. The company also has the opportunity to incorporate users in later stages by receiving ideas for the actual parts of a toy set, its promotion and marketing. This presents a growth option on the cooperation with fans. LEGO can also expand the involvement of customers to other areas of business: customers can offer new lines of products that the company could not imagine. Furthermore, LEGO can alter the scale of projects according to customers' needs and wants. For example the Architecture Eye campaign can be expanded to account for local peculiarities in the architectural style of

[132] See Zhang, X., & Zeng, P. (2007), p. 22.
[133] See Figure 6.

a country or region if that is appealing to the market. In general, involving customers is the biggest opportunity for LEGO that creates many options in the innovation and growth processes of the company.

In order to make the most value out of the underlying ROs the management of LEGO decides on pulling different levers. Since LEGO practices OI in the Research and Development phase and does not involve customers in the Maturity phase, management only influences some underlying variables.

Table 2: Comparison of theoretical levers with RO levers actually pulled by management at LEGO

	OI phase 1: Research	Phase 1 at LEGO	OI phase 2: Development	Phase 2 at LEGO
RO Lever 1: *Increase the PV of expected operating cash inflows*	by cooperating with compatible partners, low-cost suppliers, overcoming the "not invented here"-syndrome , presence of formal innovation strategy	**Achieved:** by providing numerous platforms for fan's creative suggestions	by involving reliable partners, successfully acquiring IP, prototyping, no over-engineering	**Achieved:** by systematic monitoring of customer satisfaction; securing sequential business opportunities
RO Lever 2: *Reduce the PV of expected operating cash outflows*	By systematic capturing of best ideas, reinventing fewer wheels, supporting contextual skills of partners	**Achieved:** by substituting the research department by fans' proposals	by leveraging economies of scale, scope & learning, contracting reputable partners, outsourcing standardised work	**Not attempted** by management
RO Lever 3: *Increase the uncertainty of expected CFs*	by actions related to operations, strategies and markets, not partnering with venture capitalists	**Achieved:** by customer involvement to all spheres of operation and all product lines	by encouraging complementary products and bundling	**Not attempted** by management
RO Lever 4: *Extend the opportunity's duration*	by increasing the time uncertainty of an option,	**Achieved:** by uniqueness of market offering and customer		**Achieved:** by a higher number of granted patents

	institutional and governmental support	relationship, thus holding an industry lead		
RO Lever 5: *Reduce the value lost by waiting to exercise*	by systematic capturing of best ideas, creating barriers for competitors, promoting external linkages	**Achieved:** by quickly reviewing and bringing to market winning designs	by a fast preparation and implementation of the OI project, high speed of prototyping	**Achieved:** by efficiently reviewing and launching a customer's design

When the theoretical model developed in *4.2* is tested for compatibility with the case of LEGO's OI project one can see the following communalities. LEGO opened its innovation in the first two stages of the process - Research and Development. In the Research stage, the model suggests cooperating with compatible partners and overcoming the "not invented here"-syndrome in order to increase the PV of expected operating cash inflows. This lever is successfully achieved at LEGO by providing numerous platforms for fan's creative suggestions and considering ideas for new products like the Architecture Eye. The second RO lever of reducing the PV of expected operating cash outflows is usually pulled by having a systematic approach to capturing best ideas, reinventing fewer wheels, and/or supporting contextual skills of partners. LEGO's management actually achieved it by substituting LEGO's research department by fans' proposals. Lever 3 recommends undertaking actions in company strategy and market approach in order to increase the uncertainty of expected CFs. This lever is achieved by LEGO by involving customers in all existing product lines. The 4th lever of extending the opportunity's duration is realised in theory by increasing the time uncertainty of an option. It is also realised at LEGO - through the uniqueness of their market offering and customers' relationship, which allows for an industry lead. Reducing the value lost by waiting to exercise is usually accomplished by engaging in systematic capturing of best ideas or creating business barriers for competitors. LEGO pulled that lever successfully by quickly reviewing and bringing to market customers' winning designs.

At the Development stage Lever 1 is achieved in an unconventional way: by systematic monitoring of customers' satisfaction. Theory suggests that pulling lever 2 in this stage involves leveraging economies of scale, scope & learning, contracting reputable

partners, or outsourcing standardised work. However, the management of LEGO did not attempt to pull that lever. Increasing the uncertainty of expected CFs by encouraging complementary products and bundling is also not attempted. Lever 4 is expected not to be easily pulled at this stage. Nevertheless, it is realised by a higher number of granted patents for LEGO. Lever 5 requires a successful fast preparation and implementation of the OI project and is achieved by LEGO's management by efficiently reviewing customer's designs.

Why and how can ROs be related to OI in this case?

LEGO exerts high managerial proactive flexibility when considering and executing design suggestions from customers. It captures good ideas effectively: there is an established systematic process for capturing best ideas, developing and commercialising them based on specific capabilities. "Through trial and error, LEGO has developed a solid understanding of what it takes to build and maintain profitable and mutually beneficial collaborations with users."[134]

At the **idea generation** stage flexibility for LEGO stems from collaboration with customers. This has proved to increase the underlying asset value of LEGO projects. Customers represent market needs and are at the same time the source of ideas on the Cuusoo platform, for the Architecture Eye and the Mindstorms project. This involvement creates flexibility in the way that ideas change as fast as the market needs and wants. Customers have the opportunity to use computer-aided design programs much like professional designers, architects, and engineers. Users can import and export lists of Lego parts from their designs to an online shop system and submit models. When utilising the ideas LEGO has an established formal innovation system: there is a follow-up review of all ideas with enough votes. Flexibility for LEGO also stems from understanding the economic future - again customers dictate major changes in toys' design and applicability. Considering firsthand information about business and technological trends increases the value of a project and the value of the underlying ROs. Moreover, it decreases the exercise price and uncertainty. The reason why Mindstorms is on the market is that in the digital era, LEGO just gave the direction and customers developed the idea further, tailoring it to their wants and perceptions. Moreover, the communication with fans is frequent, supported by formal and informal platforms for communication and sharing. Communication with customers is most

[134] Antorini, Y., Muniz Jr., A., & Askildsen, T. (2012), p. 74.

effective when there are several platforms for interaction provided by the company, because different users prefer different modes of communication. Generally, users do not think in value creation for the firm, therefore, there need to be clear company guidelines that screen user input of ideas. LEGO has handled this aspect by providing numerous outlets of customer creativity. Therefore LEGO Cuusoo, Architecture Eye and Mindstorms all contribute highly to the company portfolio of projects, while accounting for negligible costs.

In the **utilisation of ideas** stage there is also a positive effect on the project value from involving customers. In the case of LEGO, both the company and the fans are familiar with the existing building blocks, patterns and techniques: in that way there is technical feasibility of the partners: no expenses are needed from either side for communicating and endorsing the ideas of the partner. That increases the value of the underlying ROs for LEGO, decreases the exercise price and uncertainty. The devotion of senior management in the company increases that effect, reinforcing even higher project values and lower costs. LEGO captures good ideas effectively because it has created a solution that benefits both cooperating parties in the OI. An important step in this direction is getting over the "not invented here"-syndrome, which accounts for lower costs of research and exercise prices of underlying ROs.

In the **preparation for implementation** phase of the OI process LEGO faces flexibility in the average time it takes to launch an innovation, which is different depending on the design. Moreover, systematic monitoring of customer satisfaction is a valuable source of flexibility and should be closely observed by management. At this stage a higher number of patents translates into higher project's value and cost: according to WIPO, LEGO has more than 250 international patents as of 20.09.2012. However, the management of the company has not allowed IP protection to become legal handcuffs in innovating. Handling Mindstorms and allowing customers to upgrade existing designs without considering that an IP infringement was the best decision the company could take, resulting in popularity among fans and generating profits. What is more, since recently there is almost no use of non-disclosure agreements in the idea generation and implementation of LEGO products making the innovation process as open as possible. This allows a faster spread of ideas and upgrades, creating an efficient innovation processes. Another way that LEGO is using to benefit from its vast adult fan base is by hiring customers. Thus, the company profits from their extensive knowledge and skills and involves them further than the ideation phase of innovation.

There is no cooperation with customers at the **manufacturing and marketing** stage. The flexibility in operations for LEGO comes in the first stages of the innovation process.

LEGO has partnered up with fans in a way resembling a discovery network - uncovering of a broader spectrum of ideas is encouraged. The success of this engagement can be measured on tree levels. When searching for information LEGO is effective: it is probing ideas from customers, which ultimately drive demand. When collaboration with customers LEGO is efficient: by providing platforms like Cuusoo for communicating and sharing ideas. When scouting R&D LEGO has explored new applications of existing products, parts and software, especially in the case of Mindstorms. The company has employed an effective way of capturing value though the fan's development of designs and products, benefiting the long term relationship with customers. In LEGO the bottom line is value creation and all actions towards OI are aimed to lead to generating value for the company. The group now focuses on profitability and competitiveness by engaging customers in sequential business opportunities. That is successfully achieved by management by committing to the OI process and aligning action to company goals. In the case of LEGO management makes the most of operational flexibility within projects. It sees opportunities and the created ROs and takes them without ignoring any available information. Moreover, LEGO has created strategic flexibility between its projects involving customers.

6.2 Case 2: IBM[135]

International Business Machines Corporation (IBM) is an American multinational technology and consulting corporation. IBM produces computer hardware and software, offers infrastructure and consulting in areas from mainframe computers to nanotechnology. In 2011 it was ranked by Forbes the number 31 largest company in terms of revenues. IBM holds more patents than any other U.S.-based technology company, and has research laboratories worldwide. Among inventions of IBM are the ATM machine, the floppy disc, the hard drive disc, and the Universal Product Code, etc. Throughout its history, since its foundation in 1911, IBM has undergone several major organisational changes.

[135] See Chesbrough, H. (2003), pp. 93-113; Viskari, S., Salmi, P., & Torkkli, M. (2007), Collins, J.

By 1992 IBM was facing competitive pressure on many fronts. Its business of mainframe computers was a mature market with declining revenues. Most of the profits were coming from the PC market, but there Intel and Microsoft were taking a lead. IBM's workstation business was losing profits and reputation to Sun and Hewlett-Packard. All these dynamics have led IBM to some radical changes in corporate strategy. In 1993 Lou Gerstner was selected to head the corporation. He kept the company together instead of splitting it into smaller segments, but decided to change IBM's corporate culture altogether. In a fast developing market like that of IBM it was no longer possible to deliver best solutions to customers without cooperation from outside. The "not invented here"-syndrome had to be overcome and IBM tried to connect its technologies with other sources of solutions from external partners. IBM opened its innovation processes: it started with rethinking its selling proposition. Until 1993 one could buy an IBM chip only inside an IBM component, part of a system and service exclusively provided by IBM distribution. Then, a first contract with Apple was signed allowing the use of IBM's drives in other products. Since then IBM has gained a reputation of having a strong patenting culture, depending on royalties of licenses, manufacturing JVs, and strategic alliances.[136] Ccurrently, IBM operates in three segments: systems and financing, software, and services. It is moving from hardware to software, towards more sophisticated products and services. IBM's strategy is based on innovation and its business model tries to ensure and maintain a leader position by focusing on high-value innovation-based solutions and services.

As a good example of the implementation of IBM's strategy, a case study of the Danish leg of the international giant will be considered.[137] In 2005 IBM Denmark went into strategic collaboration with the business conglomerate Maersk. Maersk Group is primarily active in the transportation and energy sector and is the largest ship container and supply vessel operator in the world since 1996. IBM and Maersk have engaged in a global collaboration on container monitoring solutions. The idea first occurred in the shipping business, but no real proposal or plan by any company was available. The project of IBM and Maersk started with initiating a value-creation centre between the two firms, where employees working in core innovative solutions were brought together. The companies agreed on exchanging ideas and existing IPR. The result was a joint development project with merged IPR. The OI project revolved around developing

[136] See Ehrlickman R. (2006).
[137] See Working Paper complied by Monday Morning Ltd. (2007), p. 27; Emery, A. (2007, May 22).

a global container monitoring solution: a unique device that can be placed on a transporting container and that would communicate where the container is, if it has been open, shook, etc. The IBM-Maersk system uses real-time tracking devices called TRECs (Tamper-Resistant Embedded Controllers), which transmit encrypted data using a combination of wireless technologies, depending on which is available at any given point of time: wireless data networking technology from ZigBee,[138] cellular phone systems, or satellite data. In order to develop such a revolutionary product IBM needed competencies from outside. IBM's R&D cooperated with experts from Maersk and with external consultants in telecommunications. A team of around fifty people worked on the unique solution and the process continued for a couple of years. The OI project was global, as people from different countries and research centres from around the world were involved. Business knowledge and requirements were freely communicated and fed to all parties in the project, allowing for better integration. With the proceeds on the innovation, new companies with demands for similar kinds of technology were included: flight-transport companies became interested in the developed technology and inquired for its application on containers loaded into airplanes or transported by road.

Why is this case an OI example? (Refer to Chapter 2)

Due to changing market conditions and intense competitive pressure on many fronts in 1993 IBM opened up its business. Company culture was changed altogether and since then IBM is an example of openness in the field of innovation. IBM has created an ecosystem that systematically builds up on sourcing of external ideas, using pretty much every possible source to find a new business opportunity. "Instead of reinventing wheels, IBM uses them to build new vehicles for its customers - and makes money doing it."[139] In its collaboration with Maersk IBM uses both innovation push (licensing) and innovation pull (by being part of an innovation network).

[138] See ZigBee official webpage.
[139] Chesbrough, H. (2003), p. 112.

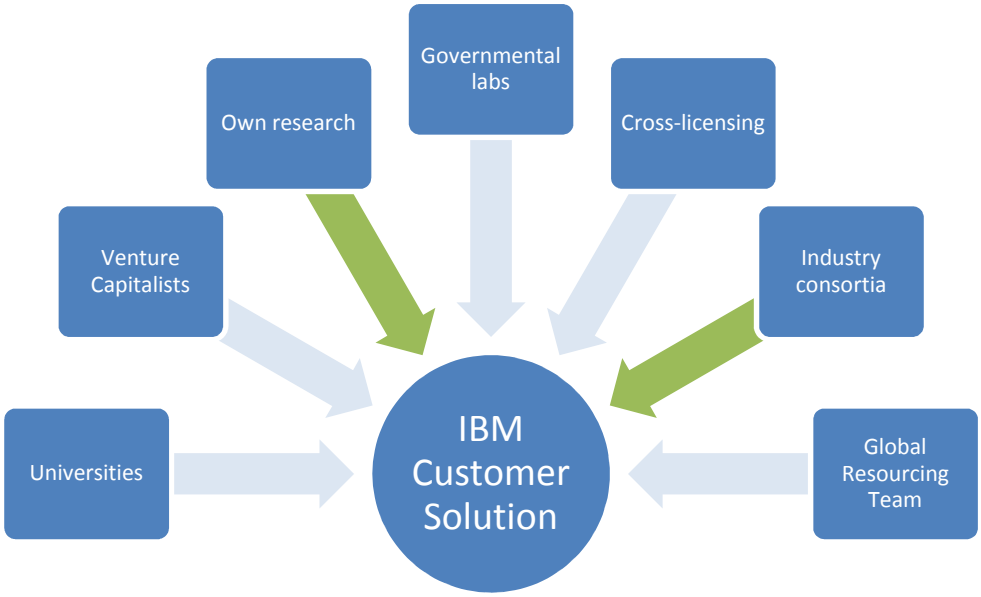

Figure 9: IBM's innovation eco system; Own research & industry consortia in the OI project with Maersk

IBM's strategic collaboration with the business conglomerate Maersk is a good example of industry consortia, which works well for a project of that type. The shipping market had undergone certain dynamics in the recent years towards more security. Therefore, the idea of developing a devise like the TRECs was already on the market. There was a need for such a product coming from many sides - harbour management and security, shipping firms and container producers. An investment in such a sphere of innovation was rational and IBM decided to act in order to outpace competition. The project is also executed by the companies that value it the most and that have resources - both IBM and Maersk are big players in their respective industry sectors.

For IBM the want phase is clear - setting innovation priorities to match market needs. IBM chose to incorporate Maersk's external expertise to satisfy demand by engaging in a partnership. The find phase is successfully managed as both companies complement respective competencies and capabilities on the project. Alignment of goals is established in the created relationship and both firms are determined to maintain a good collaboration. IBM and Maersk also coordinate and integrate resources efficiently in order to meet the specified collaborative objectives. Partnering up in this case created a network towards finding an answer to a specific problem: channeling the efforts of all parties involved in finding a solution for the market need. The long-term collaboration[140] resulted in exchanging of complementary know-how and

[140] See Reuters. (2009, December 8).

syncronisation towards a common goal. Benefits for both partners resulted from experience, standardisation and sharing of information.

The link between innovation and IBM's corporate strategy is present, promising for a successful OI project. The ownership of resources in the collaboration is also clearly defined, being a prerequisite for generating value and guaranteeing sustainability of revenues for the partnership. Product quality and reliability is expected and appears to be present as both companies agreed to prolong the contract until 2014.

Why are there ROs in this case? (Refer to Chapter 3)

Growth options exist for the project in hand. When initial activities prove to be booming the partnership has the possibility to expand activities to other clients. Other transportation sectors, beside ship freight might be targeted. The growth option is valid for both new customers and new customer segments. In this OI project where the scope is clear and the results are promising to generate profits overtime, the option to defer is not really appealing. However, there is a valid RO of expanding and altering the project's scale. The expected demand could prove to be bigger than anticipated, due to new emerging markets for the TREC devises. Therefore, changing the existing scale of the project according to market fluctuations is a valuable opportunity. A put option exists for IBM: licensing the technology and infrastructure behind the TRECs can allow the recovery of all costs of the partnership if the two companies decide to leave the idea realisation to a third party. Out-licensing a developed business case or a prototype to a third party or to Maersk can create a real opportunity for IBM. However, keeping a promising project like the TRECs is a better option in the long-term. The option to switch inputs is not of great value to IBM. Once the technology behind TRECs is developed, the sole production will not be subject to changes between production processes, or inputs. The option to stage investment in the collaboration project is viable only to the extent of upgrading the TRECs - based on a reassessment of the costs and benefits of feature extensions and new technology integration in the devises.

Initial success of the project accounts for good decision-making from management at IBM.

Table 3: Comparison of theoretical levers with RO levers actually pulled by management at IBM

	OI phase 1: Research	Phase 1 at IBM	OI phase 2: Development	Phase 2 at IBM
RO Lever 1: *Increase the PV of expected operating cash inflows*	by cooperating with compatible partners, low-cost suppliers, overcoming the "not invented here"-syndrome , presence of formal innovation strategy	**Achieved:** by cooperating with a compatible partner/ customer	by involving reliable partners, successfully acquiring IP, prototyping, no over-engineering	**Achieved:** by contracting the largest customer as a cooperating party; securing sequential business opportunities
RO Lever 2: *Reduce the PV of expected operating cash outflows*	x	x	by leveraging economies of scale, scope & learning, contracting reputable partners, outsourcing standardised work	**Achieved:** by cooperating and monitoring potential customers
RO Lever 3: *Increase the uncertainty of expected CFs*	x	x	by encouraging complementary products and bundling	**Achieved:** by investing in more perks than the market wants; expansion to market niches
RO Lever 4: *Extend the opportunity's duration*	by increasing the time uncertainty of an option, institutional and governmental support	**Achieved:** by successful IP strategy		**Achieved:** by successful prototyping; IPR
RO Lever 5: *Reduce the value lost by waiting to exercise*	by systematic capturing of best ideas, creating barriers for competitors, external linkages	**Achieved:** by merged IPR creating market entry barriers for competitors	by a fast preparation and implementation of the OI project, high speed of prototyping	**Achieved:** by making information on project publicly available - entry barrier for competitors

In the first phase of OI IBM opened its project partially - collaboration with Maersk is present only in the utilisation of ideas part of the Research phase. Therefore, levers 1, 4 and 5 are of most value for management to pull. IBM achieved increasing the PV of expected cash inflows by cooperating with a compatible partner, which is also a customer. Extending the opportunity duration and reducing the value lost by waiting to exercise is achieved by merged IP of the partners.

The TRECs project spreads the collaboration over the Development stage too. At this phase theory suggests that efficient management would easily pull all levers except for Lever 4. In the case of IBM all levers including Lever 4 are pulled successfully and in accordance with the expected theoretical cookbook. Increasing the PV of expected operating cash inflows is theoretically achieved by management if they involve reliable partners, acquire IP and engage in prototyping with no over engineering. IBM managed to make use of this most sensitive RO lever by developing a strategy around a gap in the market and by contracting the largest potential customer as a cooperating party. In this way, IBM also secured sequential business opportunities. Lever 2 is feasible through leveraging economies of scale, scope and learning, by contracting reputable partners and outsourcing standardised work. Reducing the PV of expected operating cash outflows is possible for the partnership after initial success of the TRECs. Increased market demand and expansion to other market niches would also allow use of economies of scale. Increasing the uncertainty of expected CFs can be attained by encouraging complementary products. IBM pulled that lever by investing in more advanced technologies, offering even more perquisites than the market wants at the moment of development. Moreover, encouraging the use of TRECs in other markets than the initial target market of shipping containers also creates uncertainty in both expected cash in- and out-flows. Lever 4 is not easily pulled at this stage of an OI project. However, IBM and Maersk extended the opportunity duration of their undertaking by acquiring IPR around the TRECs so that they can exclude competitors and maintain a technological lead. According to the constructed model Lever 5 - Reducing the value lost by waiting to exercise - is successfully pulled by a fast preparation and implementation of the OI project. The value lost by waiting to exercise a RO is normally lost to competition; therefore IBM has made information about the design and development of TRECs publicly available.[141] In this way, the cooperating

[141] See Brown, E. (n.d.).

parties have created a barrier for competitors to enter the market for global container-monitoring solutions.

Why and how can ROs be related to OI in this case?

The **idea generation** stage of this project does not involve OI. The market has presented its intuitive idea for a solution - a devise is needed that can allow a safer, more reliable way of tracking shipping containers and their cargo. After the problem was defined, for IBM it was left to identify relevant knowledge and create a business model involving an integrated partner. The collaboration between IBM and Maersk starts only at the utilisation stage of the project.

In the **utilisation of ideas** stage the partnership of the two companies is justified. The leading IT producer and the largest ship container operator in the world came together to execute a project involving technological expertise and knowledge about the needs and wants of vessel operators. These complementary capabilities of the partners have a positive effect on the underlying asset value of the created ROs and decrease the price of the partnership. In this OI phase, monitoring of potential customers and the market leads to longer time and lower risk of development. That is why, involving Maersk is important for IBM: Maersk is a business conglomerate, signalling market power and positively affecting the image of the partnership project. Besides a reliable partner for an ambitious undertaking, Maersk also represents the majority of the target market. Choosing a partner, which is a business leader in their respective field, is an important stepping stone for a successful innovation project. Setting up a value-creation centre between the two firms shows that enough internal work is done in both companies so that the information provided by the partners is valuable. The companies agreed on a joint development project with merged IPR, where both the price and the value will increase hand in hand with the number of filed patents. In this project the OI and business goals are aligned and account for higher value, lower price and less risk of development. The management of IBM has succeeded in creating flexibility stemming from the strategic collaboration and thus increased the underlying asset value of the project.

The **preparation for implementation** stage involves prototyping the real-time tracking devises. The combination of technologies incorporated in the TRECs requires expert knowledge from different fields: wireless networking technology, cellular phone systems, satellites, etc. In order to develop such a revolutionary product IBM needs outside competences to increase the value of the ROs on the project and decrease

uncertainty of execution. A global team of around fifty people coordinated and worked out a unique solution with high value.

When innovating, IBM creates knowledge and shares it with its employees in different functional divisions. In this way, contacts of personnel with parties from other industries can spark new customer interest. Along the successful preparation for implementation of the TRECs, companies with similar demands became interested in the technology, which increased the value and the potential market for the product. This has unveiled a possibility for strategic flexibility. IBM's management can increase the PV of expected operating cash inflows by generating and realising sequential business opportunities.

The **manufacturing and marketing** stage is executed by IBM itself: there is no openness in the manufacturing processes, as IBM has enough expertise on producing the TRECs internally.

IBM and Maersk have created a solution network towards finding an answer to a specific market need. The TRECs project is a successful engagement measured on all three levels: searching for information, collaboration and scouting R&D. When developing the devise IBM searched for information about market needs and wants by collaborating with the largest potential customer, thus being efficient in capturing future demand. When scouting R&D IBM has decided for merging newly created IP in the OI project, capturing value and benefiting from the collaboration in the long term. Although, it opened its project partially, though accurate managerial decisions, making use of existing ROs and flexibility the company innovated successfully.

6.3 Case 3: Nokia[142]

Nokia is a Finnish multinational company in the branch of communication and IT. Its main product offerings are mobile telephones and IT devices. Nokia as we know it today began its success story in 1992 with the appointment of its new CEO Jorma Ollila. In 2012 it was the second largest mobile phone maker after Samsung having sales in more than 150 countries.[143]

So far Nokia has maintained its good market position by openly innovating. It is actively engaging in OI through selective collaborations with world-leading institutions

[142] See Lindegaard, S. (2009, September 29); Estola, K.-P. (2007); Govind, S. (2012); BBC Technology. (2011, September 9); Rasmussen, L. (2012).
[143] See BBC Business. (2012, April 27).

and universities. By sharing resources, leveraging ideas and expertise Nokia has created a vibrant innovation ecosystem, through which it generates company value and ultimately end-customer satisfaction. There is a vast geographical and thematic extent of the OI network of Nokia, reflecting its ambition to tackle key technical challenges and unlock global business opportunities in collaboration with the world's best experts: "... sourcing, integration and development of product and business system innovations through win-win external partnerships to capture maximum commercial value for R&D investment."[144]

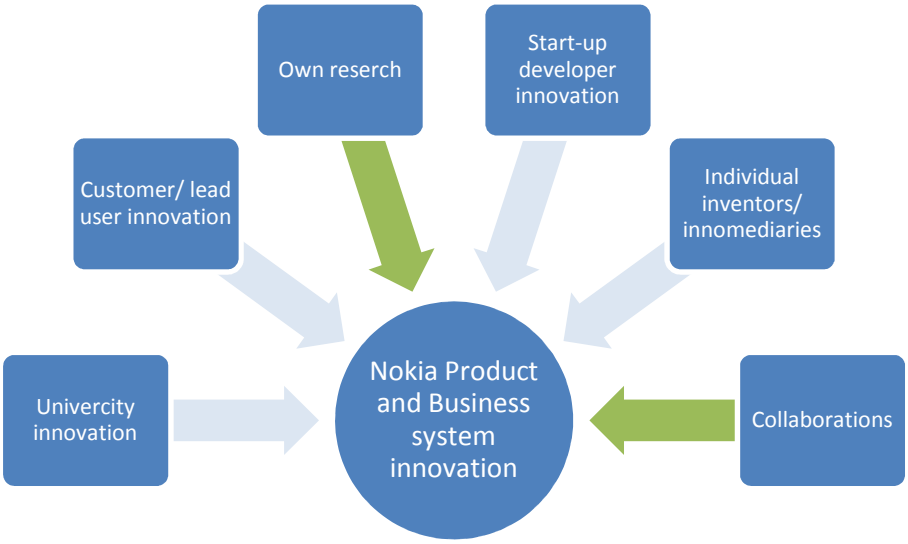

Figure 10: Nokia's main sources of OI; own research & collaboration in the smartphone OI project

Nokia had a long period of industry leadership, an impressive achievement considering the volatility of the mobile phone market. However, when the smartphone technology emerged the traditional mobile phone market shifted. New competitors from the Internet service and personal computing industries entered the smartphone branch and that shook Nokia's world. The future and competition in the smartphone industry were shifting towards software Operation Systems (OS) and applications. Therefore, in 1998 Nokia collaborated with Ericsson, Motorola and Psion to develop Symbian OS for smartphones. Although, Nokia would rather compete within the hardware part, it wanted to neutralise competition by developing an own software base. In 2002 Nokia began to focus even more on the smartphone business and invested intensely because of industry pressure from Microsoft. Nokia had a good start within the smartphone market: it was the biggest player, having approximately half of the market in 2008, but fell down to 39% in 2009. This trend continued during 2011 and Nokia was passed by

[144] Estola, K.-P. (2007).

Apple and Samsung. Both experts in the industry and Nokia itself knew that software was the differentiating part behind success in the market. It was important for Nokia to have an own smartphone OS which would secure independence, but the functionality of Symbian was not as good as Apple's iOS and the Android. Nokia reacted by hiring the former head of Microsoft's business division, Stephen Elop, as their new CEO. Elop realised that Nokia could not deliver the same experience as competitors and that something radical had to change. Therefore, in February 2011 Nokia engaged in a strategic partnership with their former competitor Microsoft.[145] Nokia incorporated Windows Phone (WP) OS on its smartphones and gradually decided to phase out its own OS Symbian. Microsoft was chosen as a partner because it had fewer hardware partners, therefore, opening more opportunities for Nokia. The deal was for Microsoft to deliver the software while Nokia provides the hardware. Nokia received $1 billion for contracting Microsoft and agreed to pay licenses for every sold smartphone with WP. Microsoft will also pay licenses for using the vast portfolio of Nokia's patents.

However, when the cooperation between Nokia and Microsoft was announced negative reactions surfaced, saying that two losers do not make a winner. Some critiques think that this is the beginning of the end for Nokia as a company and that this OI collaboration is actually the first step of Microsoft towards acquiring Nokia.[146] Others asked why it took Nokia so long to realise that their own OS solution was inadequate. Still others suggested that Nokia should not have settled for Microsoft as a single OS supplier. Employees from Microsoft were transferred to implement WP as fast as possible, while a lot of people from Nokia's development centers were laid off.[147] Moreover, coordinating a Finnish and an American organisation with the respective company structures and values proves to be difficult: both companies are large players in their industries and some friction is expected. However, Nokia and Microsoft were able to introduce their first common smartphone in November 2011, which came as a huge surprise for many.

[145] Microsoft is an American multi-national that develops, manufactures, licenses and supports a wide range of products and services related to computing. The company is the world's largest software maker in revenues.
[146] See Rasmussen, L. (2012).
[147] See Moen, A. (2011, September 30).

Why is this case an OI example? (Refer to Chapter 2)

The OI project considered here is Nokia's development of a successful smartphone. Although, some critiques consider Nokia's cooperation with Microsoft as OI at its best, it took Nokia ten years to attempt to develop own software, with very limited success.

As a rule, in the smartphone segment of the mobile industry all players engage in OI due to the dynamic technological advancements in the field. A first step for Nokia was to create a solution network towards developing an own reliable OS. However, due to slow development, operational dysfunction and higher than competitors' R&D expenses Nokia decided to abandon Symbian. While in search for regaining industry leadership within the smartphone market, Nokia decided to cooperate with Microsoft and incorporate its WP OS.

In its want phase Nokia settled down for developing an own OS solution at first. It chose to cooperate with numerous external partners in order to acquire lacking competences and resources. After an unsuccessful managing of the follow-up phases, Nokia set its priorities to cooperate with a provider of already successful phone OS. Therefore, Nokia engaged in a cooperation with Microsoft in its second attempt of a find phase, which proved more successful. A question remains if Microsoft is an optimal partner, and if it is optimal to rely on one software partner for the smartphone project. In the get phase of the OI collaboration with Microsoft Nokia established and managed a good alignment. The manage phase also ran smoothly for the two parties - easily coordinating and integrating resources to meet specified objectives.

The joint collaboration with Microsoft is aimed to oppose the strong completion in the smartphone market. With Nokia providing the hardware and Microsoft the software, better smartphone models than those based on Symbian can be expected. Moreover, both companies have a pool of valuable IPR in their respective fields and an underlying architecture of predetermined formal innovating systems dealing with IP. Thus, the collaborative project allows for the exchange of know-how and intangible assets - one of the major benefits of openly innovating. The OI resulted in launching a smartphone in a year after starting the collaboration and several upgraded models have been introduced since. Therefore, this can be considered an initial IO success, although the rollout of smartphone models can be further optimised in order to generate more value for the companies.

Why are there ROs in this case? (Refer to Chapter 3)

Nokia is considered to have underestimated the scope of its project: the importance of introducing a successful smartphone line in mobile telephony business is crucial.

There were two major pilot ROs in the development of Nokia's smartphones. The first option was to develop an own OS. In hindsight, this is an example of a bad managerial decision. The second pilot option in the smartphone launch is the cooperation with Microsoft. Now that this cooperation is a fact, there are numerous growth options that stand before the management of Nokia. So far the collaboration is successful. Therefore, the initial capacity of the existing project can increase to other products, like tablets, etc. Nokia chose to first develop an own OS for smartphones, deferring a potential cooperation with a partner offering an existing OS. When a business environment changes quickly it offers opportunities for companies to learn about expected outcomes. As a result, it can be valuable to postpone a decision. However, the smartphone sector has developed too dynamically for companies with slower reactions and a trial-and-error approach to innovating. Nokia is such a company - it waited for too long and the market changed at a faster pace than its management could anticipate. Nokia tried to be among the first to the market with an own smartphone line and an OS to support it. That meant enormous R&D costs and the returns were less than expected, resulting in time to learn and lowering the value of the next decision: cooperating with Microsoft.

A valuable critique point for Nokia is to alter the scale of its cooperation, namely to shrink it. It is suggested that the new partnership should introduce to the market less smartphone models. A strategy of introducing one product per year has proven to work for the competition from Apple and is implied to also create less competition between the Nokia smartphones themselves. Moreover, testing a new market segment with a scout product of different price range and functionality is a costly strategy for a market like the smartphone industry.

The RO to abandon Symbian is considered a competitively good decision, because it terminated costs that did not bring the expected ROI. "Nokia’s leadership is about cost, cost and cost."[148] Therefore, switch ROs are of great value to the company in every business segment of operation, including smartphone development. Nokia has factories all over the world in order to be able to respond to local demand fluctuation and make use of most optimal production patterns for its smartphone lines depending on demand.

[148] Statement of Jorma Ollila a Chairman (1999–2012) and former CEO (1992–2006) of Nokia Corporation.

Nokia is famous for its expertise in the manufacturing part and is not likely to outsource that to possible suppliers. The ROs for Nokia's smartphone project are mainly concerning the OS and the strategy behind software incorporation.

Table 4: Comparison of theoretical levers with RO levers actually pulled by management at Nokia

	OI phase 1: Research	Phase 1 at Nokia	OI phase 2: Development	Phase 2 at Nokia	OI phase 3: Maturity	Phase 3 at Nokia
RO Lever 1: *Increase the PV of expected operating cash inflows*	cooperating with compatible partners, low-cost suppliers, overcoming the "not invented here"-syndrome, presence of formal innovation strategy	**Not achieved** during Symbian: focusing on cost not quality	involving reliable partners, successfully acquiring IP, prototyping, no over-engineering	**Achieved:** by cooperating with Microsoft/ already successful OS; revenues & sequential business opportunities	supporting long-run wins and not focusing on one-off deals, monitoring of customers	**Not attempted** by management
RO Lever 2: *Reduce the PV of expected operating cash outflows*	systematic capturing of best ideas, reinventing fewer wheels, supporting contextual skills of partners	**Achieved** with Microsoft: by employing already developed & successful software	leveraging economies of scale, scope & learning, contracting reputable partners, outsourcing standardised work	**Achieved:** by making use of Microsoft's pool of patents	collaborating not just managing the relationship, production methods based on relative cost, specific about company wants	**Not achieved** with Symbian **Achieved** with Microsoft: fast integration of soft- and hardware
RO Lever 3: *Increase the uncertainty of expected CFs*	actions related to operations, strategies and markets, not partnering with	**Not attempted** by management	encouraging complementary products and bundling	**Controversially attempted**: by laying Nokia's R&D workers off	created by presence of competition	**Not achieved:** lacking dual core technology; outflows constantly exceed

	venture capitalists					inflows
RO Lever 4: *Extend the opportunity's duration*	increasing the time uncertainty of an option, institutional and governmental support	**Not attempted** by management		**Not attempted** by management	holding a technology lead, creating barriers for competitors	**Not achieved:** a viable opportunity form Microsoft collaboration - no technology lead yet
RO Lever 5: *Reduce the value lost by waiting to exercise*	systematic capturing of best ideas, creating barriers for competitors, promoting external linkages	**Not attempted** by management	fast preparation and implementation of the OI project, high speed of prototyping	**Achieved:** by outsourcing standardised work to the respective partner		**Not achieved:** Nokia decided for a cooperation too late

Nokia's OI project extends over all three phases of an innovation process: Research, Development and Maturity. In the first phase, Increasing the PV of expected operating cash inflows is achieved in theory through cooperating with compatible partners and overcoming the "not invented here"-syndrome. This RO lever is not achieved by the management of Nokia. The PV of expected operating cash outflows is normally reduced by systematic capturing of best ideas, reinventing fewer wheels, and supporting contextual skills of partners. Nokia pulled that lever successfully in cooperation with Microsoft. Lever 3, 4, and 5 at this stage were not attempted by Nokia's management. In the second phase of the OI project Lever 1 - Increasing the PV of expected operating cash inflows - is achieved through contracting Microsoft, an already successful OS supplier, accounting for revenues and sequential business opportunities. Decreasing the PV of operating cash outflows is achieved by making use of Microsoft's large pool of software patents. Lever 3 is controversially attempted by Nokia as it lay off much of its R&D workforce. Lever 4 is not easily pulled by management at this stage and the management at Nokia did not attempt to create value by extending the opportunity duration of its ROs. However, the value lost by waiting to exercise is minimised by outsourcing standardised work to Microsoft, namely the software part. In the last part of

the OI value chain of a project, Nokia's management did not attempt Lever 1 and did not achieve any of the other RO levers.

Why and how can ROs be related to OI in this case?

The OI project of Nokia to launch a successful smartphone has two major periods - the development of Symbian and the contract with Microsoft.

At the **idea generation** stage of developing Symbian the only positive aspect was ideation around building an own OS that could allow independence and guarantee company sustainability. However, there were a lot of failing areas. Nokia was too focused on costs, and if that is a strategy working well for its hardware parts, it did not help Symbian. The value of the Symbian project decreased because no uniqueness of ideas, technologies and approaches by partners was present. Moreover, employees' ideas were not always appreciated, which is an aspect that could have made Nokia's R&D investments much more efficient.

In the **utilisation and implementation of ideas** stage of Symbian Nokia could not benefit from its extensive availability of OI tools. Concerning Microsoft, synchronisation of company cultures was needed. Due to previous collaborations Nokia and Microsoft managed to create positive project value and decrease the price of the partnership. Having a large number of combined patents at this stage makes the value and the cost of the project higher. Reinventing fewer wheels and building on the research of Microsoft have decreased the cost of the smartphone project for Nokia. Both companies have managed to align their goals for a respective soft- or hardware partnership, thus increasing value, and lowering costs. Microsoft's experience with WP reduced the uncertainty for Nokia when incorporating the OS, leading to more optimal solution than that provided by Symbian. Moreover, Microsoft is a reliable partner with market influence and reputation increasing the value and decreasing the uncertainty for Nokia when collaborating. In this partnership standardised work is outsourced to the respective partner, decreasing both risk and time.

At the **manufacturing and marketing** stage Symbian is argued to have failed because of mismanagement by Nokia's executives. Nokia's main focus was on hardware and the management did not take software development seriously, even creating competitive pressures between different engineering teams. When it comes to collaboration with Microsoft on the manufacturing stage, the companies integrated impressively fast, making use of one of the most important advantages of engaging in OI. However, Nokia made some questionable decisions. Employees from Microsoft were transferred to

implement WP and people from Nokia's R&D were laid off. Incorporating temporary workforce is likely to increase the price of created ROs and considerably decrease uncertainty by a more efficient R&D department in Nokia, but also planting the fear that laid-off personnel could start working for the competition.

The presence of strong competition in the face of Apple and Samsung, increases uncertainty and decreases the time of Nokia's smartphone OI project. Moreover, competitor smartphone vendors use dual core technology, which is a setback for Nokia since WP does not support dual core technology yet.[149] Besides dual core, applications are very important for smartphone users and the collaborating parties of Nokia and Microsoft cannot manage to incentivise app developers, creating a vicious circle.

Generally, Nokia effectively uses OI strategy in the development of its new products and in setting technology standards,[150] but clearly the project of launching a smartphone is a bad example of conducting OI since Nokia lost market and deteriorated its image. Nokia lost market share when better OSs emerged, while it stubbornly kept Symbian, incurring much R&D costs and not enough returns. Nokia have already taken the first step towards repairing the scars from Symbian: a cooperation with Microsoft. As success of IO is measured along tree key dimensions - searching for information, collaboration with partners, and sourcing R&D, one can compare the two phases of the smartphone OI project. In the Symbian era Nokia was only successful in finding information for the market needs, wants and development trends, but failed on the other two fronts. In its collaboration with Microsoft one can conclude that Nokia has been successful in all three aspects of OI. Therefore, Nokia should have focused on production and cooperated with Microsoft (instead of developing Symbian) earlier.

6.4 Cases' implications

The development and management of OI relationships may be the most complex set of organisational activities carried out on a regular basis. Managers should coordinate and integrate the resources of at least two parties, each with different embedded processes and systems and do it in a market-relevant time frame.[151] Therefore, theoretical and practical similarities between executing different OI projects is of great value to

[149] See Merritt, R. (2011, April 4).
[150] See Dittrich, K., & Duysters, G. (2007), p. 520.
[151] See Slowinski, G., & Sagal, M. (2010, September-October), p. 45.

analysing and picking out best practices. The cases reviewed in this chapter show the following communalities:

- All three cases involve companies from Nordic countries, which signals for higher presence of OI practices in this region, as well as for wider availability of information on OI projects.
- Each of the companies engaged in OI after a major business crises, that has lead to loss of market share and revenues.
- In two of the cases the appointment of a new leading figure in the management of the company is associated with opening the innovation processes.
- Management's ability to choose is highly valued: management should attempt to pull as many RO levers as possible in every stage of the OI that the company is involved in.
- Management should view innovation engagement as a sequential process, in which at every step a new option is created.[152]

Table 5: Comparison between pulled levers at all stages of OI projects in the reviewed cases[153]

OI phase / **RO lever**	OI phase 1: Research - generation & utilisation of ideas	OI phase 2: Development - preparation for implementation	OI phase 3: Maturity - manufacturing & marketing
RO Lever 1: *Increase the PV of expected operating cash inflows*	LEGO: ✓	LEGO: ✓	LEGO: -
	IBM: -	IBM: ✓	IBM: -
	Nokia: ×	Nokia: ✓	Nokia: -
RO Lever 2: *Reduce the PV of expected operating cash outflows*	LEGO: ✓	LEGO: ×	LEGO: -
	IBM: -	IBM: ✓	IBM: -
	Nokia: ✓	Nokia: ✓	Nokia: ×
RO Lever 3: *Increase the uncertainty of expected CFs*	LEGO: ✓	LEGO: ×	LEGO: -
	IBM: -	IBM: ✓	IBM: -
	Nokia: -	Nokia: ×/✓	Nokia: ×
RO Lever 4: *Extend the opportunity's duration*	LEGO: ✓	LEGO: ✓	LEGO: -
	IBM: -	IBM: ✓	IBM: -
	Nokia: -	Nokia: -	Nokia: ×
RO Lever 5: *Reduce the value lost by waiting to exercise*	LEGO: ✓	LEGO: ✓	LEGO: -
	IBM: -	IBM: ✓	IBM: -
	Nokia: -	Nokia: ✓	Nokia: ×

[152] See Fredberg, T. (2007), p. 83.
[153] Managerial decisions and strategies leading to achieved (✓), not attempted (-), and not achieved (×) RO levers.

Approaching optimising OI as the practical problem it is, one needs to consider several key stages in the process: opening up, choosing partners, integrating partners, creating a formal framework for handling OI processes and emerging IPR. In the first phase of OI LEGO showed impeccable approach to integrating external expertise, that of customers and fans, into its projects. IBM chose for cooperation at a later stage, and Nokia's management either failed or did not attempt to pull all of the levers in this stage, except for Lever 2. In the second phase of OI - development and preparation for implementation - LEGO's management had success in all three levers that it attempted. However, pulling all possible levers accounts for a more flexible combined effect, as is the case of IBM. IBM's management acted and successfully pulled all five levers at this stage. Nokia had a controversial success on the levers that were pulled and again management did not attempted to influence all possible variables and levers. All three companies were successful in increasing the present value of the expected operating cash inflows and in reducing the value lost by waiting to exercise in the Development stage of their projects. In the final phase of the OI projects, LEGO and IBM did not involve eternal competences; Nokia did, but not successfully. Again, Nokia did not achieve all possible levers, having only partial accomplishment to reduce the PV of expected operation cash outflows.

Table 6: Managerial decisions leading to changes in RO levers in the OI projects of the three reviewed cases

Company		LEGO	IBM	Nokia
OI phase 1: Research - generation & utilisation of ideas	RO Lever 1: *Increase the PV of expected operating cash inflows*	**Achieved:** by providing numerous platforms for fan's creative suggestions	**Achieved:** by cooperating with a compatible partner/ customer	**Not achieved** during Symbian: focusing on cost not quality
	RO Lever 2: *Reduce the PV of expected operating cash outflows*	**Achieved:** by substituting the research department by fans' proposals	x	**Achieved** with Microsoft: by employing already developed & successful software
	RO Lever 3: *Increase the uncertainty of expected CFs*	**Achieved:** by customer involvement to all spheres of operation and all	x	**Not attempted** by management

		product lines		
	RO Lever 4: *Extend the opportunity's duration*	**Achieved:** by uniqueness of market offering and customer relationship, thus holding an industry lead	**Achieved:** by successful IP strategy	**Not attempted** by management
	RO Lever 5: *Reduce the value lost by waiting to exercise*	**Achieved:** by quickly reviewing and bringing to market winning designs	**Achieved:** by merged IPR creating market entry barriers for competitors	**Not attempted** by management
OI phase 2: Development - preparation for implementation	RO Lever 1: *Increase the PV of expected operating cash inflows*	**Achieved:** by systematic monitoring of customer satisfaction; securing sequential business opportunities	**Achieved:** by contracting the largest customer as a cooperating party; securing sequential business opportunities	**Achieved:** by cooperating with Microsoft/ already successful OS; revenues & sequential business opportunities
	RO Lever 2: *Reduce the PV of expected operating cash outflows*	**Not attempted** by management	**Achieved:** by cooperating and monitoring potential customers	**Achieved:** by making use of Microsoft's pool of patents
	RO Lever 3: *Increase the uncertainty of expected CFs*	**Not attempted** by management	**Achieved:** by investing in more perks than the market wants; expansion to market niches	**Controversially attempted**: by laying Nokia's R&D workers off
	RO Lever 4: *Extend the opportunity's duration*	**Achieved:** by a higher number of granted patents	**Achieved:** by successful prototyping; IPR	**Not attempted** by management
	RO Lever 5: *Reduce the value lost by waiting to exercise*	**Achieved:** by efficiently reviewing and launching a customer's design	**Achieved:** by making information on project publicly available - entry barrier for competitors	**Achieved:** by outsourcing standardised work to the respective partner
OI phase 3: Maturity - manu-facturing	RO Lever 1: *Increase the PV of expected operating cash inflows*	-	-	**Not attempted** by management

& marketing	RO Lever 2: *Reduce the PV of expected operating cash outflows*	-	-	**Not achieved** with Symbian **Achieved** with Microsoft: fast integration of soft- and hardware
	RO Lever 3: *Increase the uncertainty of expected CFs*	-	-	**Not achieved:** lacking dual core technology; outflows constantly exceed inflows
	RO Lever 4: *Extend the opportunity's duration*	-	-	**Not achieved:** a viable opportunity form Microsoft collaboration - no technology lead yet
	RO Lever 5: *Reduce the value lost by waiting to exercise*	-	-	**Not achieved:** Nokia decided for a cooperation too late

Comparing managerial decisions and the resulting success or failure of pulling a particular RO lever at different stages of OI projects allows for the following practical conclusions:

- Reducing the PV of expected operating cash outflows at the Research stage is usually attempted and achieved in practice by *substituting own research for employing already existing solutions*.
- Successfully extending the opportunity's duration at the Research stage of an OI project is associated with *managing intangibles*: LEGO achieved this lever by the uniqueness of its market offering and customer relationship, IBM - by successful IP strategy.
- At the Development phase, increasing the PV of expected operating cash inflows is achieved with different measures, but they have all lead to *securing sequential business opportunities*.

- Extending the opportunity's duration at the Development phase is attempted and achieved by two of the companies (LEGO and IBM) and they both used *IP to achieve it*.
- The more options present in the operations of a company, the higher the chance to increase the value of an OI project.

What more can be learned from the cases is that managing OI projects entails a series of trade-offs and for different innovations different sources of uncertainty exist. Normally, barriers for starting to openly innovate prove to also be weak points in the further execution of OI projects. A key in OI projects is not to manage risk down to zero, but to manage uncertainty proactively. Theoretical and practical implications are outlined in the next chapter. Moreover, due to the restricted scope and time of the conducted research some limitations and advice for future scientific developments on the topic are suggested.

7 Concluding remarks and discussion

7.1 General results and practical implications

The focus of this research has a challenge of both scientific and practical nature combining two attractive research fields in recent years: valuation and OI. OI is an interactive system in which multiple agents are involved and it represents a collection of processes, some of which are directly controlled by users.[154] However, there is no clear method for taking decisions in OI projects. The objective of this thesis is to create a framework for managerial decision-making that, if applied, can improve the outcomes of OI projects. The resultant model is a ROs approach to OI investment measuring flexibility through the value of existing ROs.[155] It involves managerial decisions taken at every phase of an OI project, which influence underlying project variables and if exercised effectively create flexibility. My model uncovers which variables are most easily influenced by management and at which stage they create the most value.[156] The backbone of my work is *Table 1: RO levers that management can most easily pull at each stage of an OI project*, which gives concrete advice that proactive managers can apply to solve the complexity of a particular project.

- ✓ Managers can and should influence the values of underlying resources through strategic actions[157] - by pulling different RO levers at different stages of an OI project.
- ✓ At different OI phases, certain levers are more easily influenced.
- ✓ A company does not need to open its innovation processes at all three phases (Research, Development, Maturity), but should attempt to pull all RO levers at the phases it chose to cooperate with partners in order to create more value.
- ✓ The ROs need to be measurable (scale, range, comparability).
- ✓ A balance is needed between keeping options open and the need to make a decision and act.
- ✓ Flexibility is only valuable if companies have adequate tools to benefit from optionality,[158] such as anticipation and reaction capabilities.[159]

[154] See Harrison, M.D. (1992), p. 160.
[155] See Jaegle, A. (1999), p. 287.
[156] See Luehrman, T. (1998 a), p. 90.
[157] See Miller, K., & Waller, H. (2003), p. 105.
[158] See Kogut, B., & Kulatilaka, N. (1994).
[159] See Verganti, R. (1999), p. 368.

Besides value to managers and practitioners in the field, my model also has strengths in scientific worth. It treats OI as a staged process and analysis is conducted on each phase. In this way, a narrower view can be taken on existing internal and external influencing factors determining the values of project variables. ROs contribute to the analysis by embedding a firm's ability to sequence and stage investments in the face of uncertainty. Flexibility is chosen as a key variable to be operationalised and to support the link between OI and ROT. This is a valuable scientific insight because flexibility is the most intuitive connecting variable, not yet broadly analysed by scholars of both fields.

Moreover, the model and in particular the managerial practises outlined in *Table 1* allow scientists and practitioners to uncover similar approaches of different companies to pull same levers. A cookbook on pulling levers leads to uncovering best practices, most used approaches, unique sloutions and serves as a tool for staged decision-making in the OI process.

7.2 Study limitations and recommendations for future research

OI is a multifaceted concept: it comes in many forms and tastes. Therefore, it is necessary to develop different frameworks to reviewing it.[160] In this thesis the focus is on viewing OI as a process and operationalising flexibility in OI projects. Furthermore, the value of existing and created by managerial decisions flexibility is assessed by the RO valuation method.

Future research could expand my method by analysing OI in a different framework - a broader viewpoint can be taken, seeing OI as a company culture, etc. Further in-depth investigation of OI through a ROs lens can take the analysis to a new level - deepening the understanding of operationalising flexibility. Also, other variables could be used to make the link between OI and ROT more explicit; future analysis can expand to more than one variable. Thorough review of a larger sample of case studies according to *Table 1: RO levers that management can most easily pull at each stage of an OI project* would allow for valuable generalisations and comparisons between best practices in different industries. Both scholars and practitioners can greatly benefit from further scientific developments on the topic of "Identifying flexibility in the Open Innovation process based on Real Option Theory" using the method I have proposed.

[160] See Huizingh, E. (2010), p. 2.

Naturally, the approach I have undertaken, and the empirical illustration of my model have some limitations. First, the choice of operationalising flexibility may seem restrictive, but my decision is to tackle only one of the many possible links between OI and ROT. Second, as empirical support of my analysis a case study approach is undertaken in a restricted number of companies. These, pose some questions on the breadth of application of the analysis. Moreover, as it can clearly be seen all three cases are of Nordic companies, which signals for a biased sample - due to limited availability of exhaustive publications on OI projects. What is more, the companies operate in different businesses, which prohibits a broader view on one industry. On the data analysis front one of the difficulties is a precise recognition and assessment of flexibility in firm operations. Depth of analysis is restricted due to the reluctance of companies to provide extensive information about their OI projects, because it is of great value. More extended investigations, i.e. surveys,[161] interviews, and quantitative tools of data analysis could be recommended for future research.[162]

My research is applying already existing strategic levels of analysis, combining them and developing them a step further to incorporate more predictors operationalising flexibility. Thus, a satisfactory reaction to the model I have developed would be its consideration as obvious and intuitive for depicting OI engagements as a firm strategy and viewing them through ROs in order to arrive at concrete recommendations.

[161] See A1 in the appendix.
[162] See de Massis, A., Lazzarotti, V., Pizzurno, E., & Salzillo, E. (2012), p. 235.

Bibliography

Adner, R., & Levinthal, D. (2004). What is not a real option: considering boundaries for the application of real options to business strategy. *The Academy of Management Review , 29* (1), 74-85.

Ahuja, G. (2000). Collaboration, Networks, Structural Holes, and Innovation: A Longitudinal study. *Administrative Science Quarterly,University of Texas at Austin , 45*, 425-455.

Antorini, Y., Muniz Jr., A., & Askildsen, T. (2012). Collaborating with customer communities: lessons learned from LEGO Group. *MIT Solan Management Review , 53* (3), 72-79.

Benaroch, M. (2001). Option-based management of technology investment risk. *IEEE Transactions on Engineering Management , 48* (4), 428-444.

Black, F., & Scholes, M. (1973). The pricing of options and corporate liabilities. *the Journal of Ploitical Economy , 81* (3), 637-654.

Boer, P. (2000). Valuation of technology using "Real Options". 1-9.

Bogdan, B., & Villiger, R. (2010). *Valuation in life sciences: a practical guide* (3rd ed.). Springer.

Bollen, N. (1999). Real options and product life cycles. *Management Science , 45* (5), 670-684.

Borison, A. (2005). Real options analysis: where are the emperor's clothes? *Journal of Applied Corporate Finance , 3* (2), 17-31.

Broadie, M., & Detemple, J. (2004). Option pricing: Valuation models and application. *Management Science , 50* (9), 1145-1177.

Bughin, J., Chui, M., & Johnson, B. (2008, June). The next stap in open innovation. *The McKinsey Qarterly* , 1-8.

Carney, P., & Ryan, M. (2010). Measuring firm-level innovation: review of the literature & survey-design. *UCD Geary Institute* .

Chao, R., & Kavadias, S. (2008). A theoretical framework for managing the new product development portfolio: when and how to use startegic buckets. *Management Science , 54* (5), 907-921.

Chesbrough, H. (2004). Managing Open Innovation. *Research Technology Management* , 23-28.

Chesbrough, H. (2003). *Open innovation: The new imperative for creating and profiting from technology.* Harvard Business Review Press.

Chesbrough, H., & Appleyard, M. (2007). Open innovation and strategy. *California Management Review , 50* (1), 57-76.

Chiaroni, D., Chiesa, V., & Frattini, F. (2009). *The Open innovation journey: How firms dynamically implement the emerging innovation management paradigm.* Milano: Politecnico di Milano, Dipartamento di Ingegneria Gestionale.

Copeland, T., & Keenan, P. (1998). Making real options real. *The McKinsey Quarterly , 3*, 128-141.

Copeland, T., & Tufano, P. (2004). A Real-world way to manage real options. *Harward Business Review* , 1-11.

Copeland, T., & Weiner, J. (1990). Proactive management of uncertainty. *The McKinsey Quarterly , 4*, 133-152.

Copeland, T., Koller, T., & Murrin, J. (1994). *Valuation: Measuring and managing the value of companies.* New York: John Wiley & Sons.

de Backer, K., Lopez-Bassols, V., & Martinez, C. (2008). Open innovation in a global perspective: what do existing data tell us? *OECD Science, Technology and Industry Working Papers , 4*, 1-37.

de Massis, A., Lazzarotti, V., Pizzurno, E., & Salzillo, E. (2012). Open innovation in the automotive industry: a multiple case-study. (H. Sun, Ed.) *Management of Technological Innovation in Developed Eountries* , 217-236.

Dittrich, K., & Duysters, G. (2007). Networking as a means to strategy change: the case of open Innovation in mobile telephony. *The Journal of Product Innovation Management , 24*, 510-521.

Dixit, A., & Pindyck, R. (1995, May-June). The options approach to capital investment. *Harvard Business Review* , 105-118.

Dodgson, M., Gann, D., & Salter, A. (2006). The role of technology in the shift toward open innovation: the case of Procter & Gamble. *R&D Management , 36* (3), 333-346.

Driouchil, T., & Bennett, D. (2012). Real Options in Management and Organisational Strategy: A review of Decision-making and Performance Implication. *International Journal of Management Reviews , 14*, 39-62.

Dyer, J., Kale, P., & Singh, H. (2004). When to Allay, When to Acquire? *Harward Business Review , 82* (7/8), 108-115.

Edelson, D. (2002). Design Research: What we learn when we engage in design. *Journal of the learning Sciences , 11* (1), 105-121.

Enkel, E., Grassmann, O., & Chesbrough, H. (2009). Open R&D and Open innovation. *R&D Managemnt , 39* (4), 311-316.

Estrada, I., de la Fuente, G., & Martin-Cruz, N. (2010). Technological joint venture formation under the real options approach. *Research Policy , 39*, 1185-1197.

Fredberg, T. (2007). Real options for innovation management. *International Journal of Technology Management , 39*, 72-85.

Gil, N. (2007). On the value of project safeguards: Embedding real options in complex products and systems. *Research Policy , 36*, 980-999.

Govind, S. (2012). Microsoft's strategic alliance with Nokia. *IBS Center for management research* , 1-15.

Grassmann, O. (2006). Opening up the innovation process: towards an agenda. *R&D Management , 36* (3), 223-228.

Hansen, M., & Birkinshaw, J. (2007). The Innovation Value Chain. *Harvard Business Review* , 1-14.

Harrison, M. (1992). A model for the option space of interactive systems. *Engineering for Human Computer Interaction* , 150-170.

Hommel, U., & Pritsch, G. (1999). Marktorientierte Invetitionsbewertung mit dem Realoptionsansatz. *Finanzmarkt-und Portfoliomanagement , 13* (2), 121-144.

Huchzermeier, A., & Loch, C. (2001). Project management under risk: using real options approach to evaluate flexibility in R&D. *Management Science , 47* (1), 85-101.

Huizingh, E. (2010). Open innovation: State of the art and future perspectives. *Techovation* , 1-8.

Jaegle, A. (1999). Shareholder value, real options, and innovation in technology-intensive companies. *R&D Management , 29*, 271-287.

Kang, Y. (2007). *Real option valuation of product innovation.* Hamburg: Diplomarbeit, Diplomica Verlag GmbH.

Katzy, B. (2003). *Integrating real-options reasoning and the innovation diffusion curve for decision making under uncertainty.* University Bw Munich.

Kester, W. (1984). Today's options for tomorrow's growth. *Harvard Business Review , 62* (2), 153-160.

Kirschbaum, R. (2005). Open Innovation Practice. *Reserch Technology Management* , 24-28.

Kogut, B., & Kulatilaka, N. (2001). Capabilities as real options. *Organization Science , 12* (6), 744-758.

Kogut, B., & Kulatilaka, N. (1994). Operating flexibility, global manufacturing and the option value of a multinational network. *anagement Science , 40* (1), 123-139.

Koussis, N., Martzoukos, S., & Trigeorgis, L. (2006). *Real R&D options with time-to-learn and learning-by-doing.* Univercity of Cyprus.

Leslie, K., & Michaels, M. P. (1997). The real power of real options. *The McKinsey Quarterly , 3*, 4-22.

Levinthal, D. (2004). What is not a real option: considering boundaries for teh application of real options to business startegy. (R. A. Insead, Ed.) *Academy of Management Review , 29* (1), 74-85.

Lindegaard, S. (2011). *Making open innovation work.* North Charleston: Library of Congress Control.

Lint, O., & Pennings, E. (2001). An option aproach to new product development process: a case study at Phillips Electronics. *R&D Managemen , 31* (2), 163-172.

Luehrman, T. (1998 b, July-August). Investment opportunities as Real Options: Gettng started on the numbers. *Harvard Business Review* , 51-67.

Luehrman, T. (1998 a). Strategy as a portfolio of real options. *Harvard Business Review* , 89-99.

Mathews, S. (2009). Valuing risky projects with real options. *Research Technology Management , 52* (5), 32-41.

McGrath, R. (1997). A Real Options Logic for Initiating technology Positioning Investments. *The Academy of Management Review , 22* (4), 974-996.

McGrath, R., & Nerkar, A. (2004). Real options reasoning and a new look at the R&D investment strategies of pharmaceutical firms. *Strategic Management Journal , 25* (1), 1-21.

Miller, K., & Waller, H. (2003). Scenarios, Real Options and Inegrated Risk Management. *Long Range Planning , 36*, 93-107.

Monteiro, F., Cachon, G., & Cappelli, P. (2012, February 1). The 'Flip Side' of open innovation, Productivity Losses from Bad Weather and Assessing the Risks of Outsourcing. *Knowledge at Wharton* , 1-5.

Morris, L. (2008). Innovation Metrics: The innovation process and how to measure it. *Innovation Labs LLC* , 1-19.

Mun, J. (2006). *Modelling risk: applying Monte Carlo simulation, real option analysis, forecasting, and optimization techniques.* Hoboken, New Jersey: John Wiley & Sons, Inc.

NESTA Making Innovation Flourish. (April 2010). Open innovation from marginal to mainstream. 1-23.

O'Brien, J., Folta, T., & Johnson, D. (2003). A Real options perspective on entrepreneurial entry in the face of uncertainty. *Managerial and Decision Economics , 24*, 515-533.

Pontinskoski, E., & Asakawa, K. (2009). Overcoming barriers to Open Inovation at Apple, Nintendo and Nokia. *World Academy of Science, Engineering and Technology , 53*, 372-377.

Rasmussen, L. (2012). *Optimizing Open Innovation with Nokia as a case.* Aarhus School of Business, Aarhus Univercity.

Roper, S., Du, J., & Love, J. (2008). Modelling the innovation value chain. *Research Policy , 37*, 961-977.

Santiago, L. (2008). An empirical investigation on the appropriateness of flexibility approach to the product portfolio selection. *International Journal of Technology Management , 44*, 251-268.

Schiele, H. (2006). How to distinguish innovative suppliers? Identifying innovative suppliers as new task for purchasing. *Industrial Marketing Management , 35*, 925-935.

Slowinski, G., & Sagal, M. (2010, September-October). Good practices in open innovation. *Research Technology Management* , 38-45.

Smith, J., & Nau, R. (1995). Valuating Risky Projects: Option Pricing Theory and Decision Analysis. *Management Science , 41* (5), 795-816.

Stone, A., Rose, S., Lal, B., & Shipp, S. (2008). *Measuring Innovation and Intangibles: A Business Perspective.* Washington: Institute for Defence Analyses Science & Technology Policy Institute.

Tether, B. (2002). Who co-operates for innovation and why, an empirical analysis. *Research policy , 32*, 947-967.

Tidd, J., Bessant, J., & Pavitt, K. (2005). *Managing Innovation: Integrating Technological, Market and organisational change* (3rd ed.). John Wiley & Sons, Ltd.

van de Vrande, V., Lemmens, C., & Vanhaverbeke, W. (2006). Choosing governance models for external technology sourcing. *R&D Management , 36* (3), 347-363.

van Putten, A., & MacMillan, I. (2004, December). Making real options real. *Harward Business Review* , 1-8.

Vanhaverbeke, W., van de Vrande, V., & Chesbrough, H. (2008). Understanding the advantages of Open Innovation Practices in Corporate VBenturing in terms of Real Options. *Creativity and innovation Management , 17* (4), 251-258.

Verganti, R. (1999). Planned flexibility: linking anticipation and reaction in product development projects. *Journal of Production Innovation Management , 16* (4), 363-376.

Viskari, S., Salmi, P., & Torkkli, M. (2007). *Implementation of open innovation paradigm; Cases: Cisco Systems, DuPont, IBM,Intel, Lucent, P&G, Philips and Sun Microsystems.* Lappeentranta: Tutkimusraportti - Research Report 189.

Wallin, M., & von Krogh, G. (2010). Organizing for open innovation: Focus on the integration of knowledge. *Organisational dynamics , 39* (2), 145-154.

Working Paper complied by Monday Morning Ltd. for Danish Ministry of Science, Technology and Innovation. (2007). Open Innovation case studies from Denmark. *OECD Project Globalisation and Open Innovation* , 1-30.

Wouters, M., Roorda, B., & Gal, R. (2011). Managing uncertainty during R&D projects: a case study. *Research Technology Management* , 37-46.

Zhang, X., & Zeng, P. (2007). Enterprise Innovation and Real Option. *School of Humanity and Management, China Univercity of Geology, Beijing* , 21-25.

Internet Sources

Alphaliner. (2011). *Weekly Newsletter.* Retrieved September 28, 2012, from http://www.alphaliner.com/liner2/research_files/newsletters/2011/no08/Alphaliner%20Newsletter%20no%2008%20-%202011.pdf

BBC Business. (2012, April 27). *Samsung overtakes Nokia in the mobile shipments.* Retrieved September 23, 2012, from http://www.bbc.co.uk/news/business-17865117

BBC Technology. (2011, September 9). *Nokia at Crisis Point, Warns new Boss Stephen Elop.* Retrieved September 30, 2012, from http://www.bbc.co.uk/news/technology-12403466

Blog, L. C. (2012, May 22). *The quarterly LEGO review: How does it work?* Retrieved from http://lego.cuusoo.com

Brown, E. (n.d.). *IBM Publications Eric Brown.* Retrieved October 10, 2012, from http://researcher.watson.ibm.com/researcher/view_pubs.php?person=us-ewb&t=1

Collins, J. (n.d.). *IBM, Maersk Developing Cargo Tracker.* Retrieved September 28, 2012, from http://www.rfidjournal.com/article/view/1884

Cooper, R. (2010, November 16-17). *Open Innovation with stage-gate.* Retrieved June 9, 2012, from www.stage-gate.com

Emery, A. (2007, May 22). *A.P. Moeller-Maersk and IBM in 5-Year Agreement.* Retrieved September 28, 2012, from IBM Media relations: http://www-03.ibm.com/press/us/en/pressrelease/21588.wss

Empirica. (2011, August 26). *Pro Inno Europe.* Retrieved June 3, 2012, from europe http://www.proinno-europe.eu/inno-grips-ii/article/measuring-open-innovation-inno-grips-study-tackles-challenging-task

Estola, K.-P. (2007). *Nokia Research Center.* Retrieved September 23, 2012, from http://www.scribd.com/doc/430077/Open-Innovation

Jaruzelski, B., & Holman, R. (2011, May 3). *The three paths to open innovation.* Retrieved June 3, 2012, from Strategy Business: www.strategy-business. com

LEGO Official Webpage. (n.d.). Retrieved September 3, 2012, from http://www.lego.com/en-us/Default.aspx

LEGO CUUSOO Blog (2012, May 22). *The quarterly LEGO review: How does it work?* Retrieved from http://lego.cuusoo.com

Lindegaard, S. (2009, September 29). *Nokia and open innovation: a good match?* Retrieved September 23, 2012, from 15inno: http://www.15inno.com/2009/09/27/nokia/

Lindegaard, S. (2011 b, November 18). *Innovation Excellence.* Retrieved June 9, 2012, from http://www.innovationexcellence.com/blog/2011/11/18/legos-50-million-open-innovation-failure/

Merritt, R. (2011, April 4). *Nokia may lag shift to dual-core phones.* Retrieved September 30, 2012, from http://www.eetimes.com/electronics-news/4215741/Nokia-may-lag-shift-to-dual-core-phones

Moen, A. (2011, September 30). *Corporate News: Nokia Cuts 3,500 Manufacturing Jobs.* Retrieved September 30, 2012, from Wall Steet Journal: http://online.wsj.com/article/SB10001424052970204226204576600130074355052.html

Open your innovation Blog (2010, April 1). *Open Innovation, crowdsourcing and the rebirth of LEGO.* Retrieved June 8, 2012, from http://open-your-innovation.com/2010/04/01/open-innovation-crowdsourcing-and-the-rebirth-of-lego/

Open your innovation Blog (2012, May 16). *Open innovation at LEGO- an interview with Erik Hansen, Senior director,Technology and innovation at the LEGO Group.* Retrieved June 10, 2012, from , http://open-your-innovation.com/2012/05/16/open-innovation-at-lego-an-interview-with-erik-hansen-senior-director-technology-open-innovation-at-the-lego-group/

Reuters. (2009, December 8). *Maersk extends IBM data services deal to 2014.* Retrieved September 28, 2012, from : http://www.reuters.com/article/2009/12/08/maersk-ibm-services-idUSGEE5B70BE20091208

World Intellectual Property Organization (WIPO). (n.d.). Retrieved September 4, 2012, from http://www.wipo.int/portal/index.html.en

ZigBee Official Website. (n.d.). Retrieved September 28, 2012, from http://www.zigbee.org/

Appendix

A1: Extended research sub-questions for identifying flexibility points

1) What is the flexibility a company faces in the generation of ideas phase of the OI process?

➔ Does a company work with external partners?

➔ What is the frequency of networking with partners/ potential partners?

➔ To what extent do generated ideas come from within the company?

➔ Is there a presence of formal innovation system in the firm?

➔ Is there cross-functional collaboration in innovation/ other processes in the firm?

➔ What is the percentage of external relationships involving R&D?

➔ What percent of internal ideas are offered for external license?

➔ Do the generated ideas change as fast as the market?

➔ Is there a balance between breakthrough and incremental projects' ideas?

➔ People collaborating across units produce enough good ideas.

2) What is the flexibility a company faces in the utilization of ideas phase of the OI process?

➔ Is there cross-pollination present in innovation collaboration?

➔ Is there a presence of formal innovation system in the firm?

➔ What is the percentage of generated ideas selected to go to the next stage of innovation?

➔ Does the actual portfolio of generated ideas correspond to the planned/intended?

➔ How well is the emerging economic future understood?

➔ Is the innovation portfolio balanced correctly?

➔ What is the % of investment in non-core innovation projects?

➔ What is the number of patents filed?

➔ What is the % of ideas generated that end up being selected and funded?

3) What is the flexibility a company faces in the preparation for implementation phase of the OI process?

➔ Is there a dedicated R&D budget present?

➔ Are there publications made for an innovation by the firm at this stage?

- ➔ How many R&D hours are spent on a particular innovating?
- ➔ What is the number of outsources projects
- ➔ What is the speed of prototyping? Number of prototypes per new product?
- ➔ What is the average time it takes the firm form first to last stage of the innovation process?

4) What is the flexibility a company faces in the manufacturing and marketing phase of the OI process?

- ➔ What is the number of collaborative projects? (manufacturing)
- ➔ Do innovation projects involve team members from different units of the organization?
- ➔ Do innovation projects involve team members from different partner firms?
- ➔ Is the percentage of penetration in the desired market above/ below expected?
- ➔ Is there a systematic monitoring of customer satisfaction?
- ➔ Are all possible customer groups reached?
- ➔ What is the % of funded ideas that lead to revenues?
- ➔ What percent of sales of products/services come from externally licensed technologies?
- ➔ What percent of net income for last year came from externally licensed technology? Is there a trend of increase or decrease?

A2: Positive and negative effects of concrete managerial decisions

ROs associated with a managerial decision	+ Concrete managerial decision with positive effect on the affected variable	- Concrete managerial decision with negative effect on the affected variable	Affected variable
Pilot	Partnering up with venture capitalists	Sustaining internal R&D investments	X, δ
Pilot	Leverage external resources	Not knowing how to open up/how to make the shift	X, σ ,t
Pilot	Aligning current abilities and capabilities of a firm to an aimed-for OI strategy	Separation of a company‘s current R&D and a wished OI strategy	X
Pilot	Include different departments: going beyond R&D and marketing	OI applied wrongly, or OI is the wrong strategy	X
Pilot	Involvement of senior-level executive champion	Managers do not notice the need for innovation/ benefits of OI→ organisational inertia	X, S, t
Pilot	Promoting external linkages: forums, seminars, assign internal employees to interact with scholars	Lack of ability to build partner relationship and trust	t
Pilot	Clearly communicate that OI is an industry phenomenon and not the initiative of one company	Wrong communication of the OI culture	S, t
Pilot	Set up internal venture capital group to commercialize ventures out of research labs/partnerships	Hinder formation of spin-offs	X, S
Pilot, growth	Enough internal work is done so that external information is valuable	Contextual skills are not supported, unable to partner-up effectively	X, S
Pilot, growth	Reinventing fewer wheels: building on the research of others and transferring those discoveries into the company’s own development process	Extensive use of external knowledge can prove to be a limitation	X
Pilot, growth	Establishing a systematic process for capturing best ideas; develop and commercialize based on specific capabilities	Random evaluation of ideas, different criteria and evaluation processes	X, σ
Pilot, growth	Early investments that have to be abandoned can be valuable to another business unit	Barriers to entre/implement OI in the first place are later on weak points in the OI	S

	within the same company	project management	
Defer, pilot	Align business and OI goals	Innovation goals not aligned with business goals	X, S, σ
Defer, scale	Devoted senior management	Lack of senior management commitment to OI	X, S, σ
Abandon or license	An initial idea can be modified (change of its application, target market, etc.) and licensed in or out	Abandoning a project not profitable for the company, restricting licenses on this project and preventing spin-off formations	X, S
License	Offer unused IP outside of the company: holding an unused IP is a waste of resources and decreases the motivation of employees	Confidentiality and IP issues at the early stages of building the OI community	X, δ
License	Adequate IP policies should be agreed upon in advance-allowing for proper licensing of external ideas	IP protections become legal handcuffs and restrict opportunities via an excessive restriction to risk	X, S, δ
License	Using both formal and informal methods of protection to capture the value of OI: most importantly focus on the appropriation of value and not so much the method	No outbound innovation: fear to give away corporate "crown jewels"	X, S, δ
Abandon	Managing an OI relationship means making it work or "cutting the bait when it no longer makes sense"	Strategies and innovation usually fail because of poor execution of ideas	X, σ, δ
Switch	Changing production methods, inputs, or geographical location of based on relative cost	Unable to see lower cost of inputs and or methods, thus incurring higher costs	X, S
Switch	Clearly communicating company needs	Not communicating changes in company needs, inertia of partners' assumptions and actions	X, σ
Stage	Reassessment of costs and benefits of previous OI stage	Not acting on resolved uncertainties from previous OI stage	X, S, σ
Compound	Capture good ideas effectively: creating solution that benefit both parties in the OI	Information sharing as a main issue	X, S, t
Compound	Bring focus to the effort: helping external partners by being specific what the company wants in terms of innovativeness	Thinking in terms of one-off deals: no wins in the long run	X, S, σ, t
Compound	Learning from customers:	"not invented here"-	X, S

	customers get a solution to a specific problem, the firm preserves the rights to apply that solution to other cases and owns any IP that resulted in the solution process[163]	syndrome	
Compound	Creation of new organisational units: IP unit to manage the existing and new knowledge	No openness towards IP	X
Compound	Consider firsthand information about business and technological trends		X, S, t, σ
Compound	Protect the OI partnership from short-term pressures	Trying to manage the process instead of collaborating	X, S, σ
Compound	Manage the whole portfolio of OI projects, not projects individually	Various organisational units are not fully aligned with the OI initiative	σ
Compound	The bottom line is value creation: all actions towards OI should lead to creating value for the company	Conduct research, but unable to profit from it	S

[163] See Chesbrough, H. (2003), p. 110.

Oath

I declare that I have prepared the paper at hand independently and without the help of others and that I have not used any other sources and resources than the ones stated. Parts that have been taken literally or correspondingly from published or unpublished texts or other sources have been labeled as such.

This text has not been presented to any examination board in the same or similar form before.

Evgenia Terzieva Date: 10.11.2012